

CONTRACTS, SPECIFICATIONS

AND

ENGINEERING RELATIONS

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PREFACE

In the following pages the author has discussed some of the important relations of the engineer and architect in practical life, with which it seems essential that the technical man should become familiar before entering professional practice. Legal and contractual relations are but briefly discussed, as these subjects are fully treated in many valuable works to which it is intended that these notes shall serve simply as an introduction. The principles of personal and ethical relations, while discussed in somewhat greater detail, are but inadequately treated on account of the lack of space. The preparation of specifications is discussed in greater detail as less published matter is available on this subject.

The young man who enters any vocation comes in contact with and is sometimes employed by men who disregard professional and business ethics and do many things which, while perhaps in entire conformity with law, are far from the ideals of ethical conduct. If a young man has given no thought to moral and ethical principles, he is apt to assume that such principles are cant and that unethical methods and actions are common to all those in business and professional life and are therefore essential to his personal success. He should therefore be advised and assured of the facts in the case: that the best and most successful men in every business and profession are those men of high ideals whose honesty and integrity are unquestioned and whose character and reputation are regarded as the greatest and most valuable of their possessions.

The author has uniformly advocated the "square deal" in the relations of the engineer and architect with the contractor and with all others with whom they may have relations. He believes that honesty, integrity, and fairness afford the best possible basis for practical professional and business life and are not simply principles to be acknowledged and ignored. He believes that the appreciation of these principles will lead to the highest type of work, the most economical construction, and the greatest professional satisfaction.

In the study of specifications, little advance can be made by an attempt to prepare at once an elaborate specification for a complicated engineering structure of which the student knows nothing. In such a case, all that can be expected is the copying, with perhaps some small changes, of similar specifications prepared for some proposed or completed work, and such practice will be of little value.

In the teaching or study of any subject, success comes through the ability of the teacher or student to simplify the subject so that its basic principles may be easily comprehended; the greatest difficulties follow an attempt to attack the subject in a too complicated manner.

The principles and elements of specification writing should be acquired through the actual preparation of specifications for simple materials or elements and for simple processes or structures. All work should be simplified as much as possible; it must be so defined and illustrated that the problems involved will be clearly comprehended; it must be analyzed in detail so that every phase and item shall be seen and appreciated. If this can be successfully accomplished with simple elements of material or construction, it can then be applied to more complex subjects, which are simply a combination of such elements.

In the preparation of specifications there is no more important matter than the use of good English. A correct thought improperly expressed is often as serious as though the idea itself were in error. A clear description of simple subjects should therefore be the object of preliminary practice. In many cases all the specifications essential are included in a letter, and many contracts are actually consummated by an offer transmitted by letter and by a letter of acceptance.

By practice along the lines indicated, the young engineer will at least acquire an intelligent method of procedure, and if the method is understood, the professional application may be safely left to individual initiative.

The analytical system suggested for the preparation of specifications has been used by the author for nearly thirty years, and is believed to afford a safe and logical method for the preparation of these papers.

This book was first issued in the spring of 1916 for the author's class and for private circulation. Of those to whom copies were sent, constructive criticism was requested. A number of valuable suggestions were received, and the book has been rearranged, revised and enlarged in this first edition. The author is aware that there are still numerous changes and additions that can be made to advantage, and hopes to make material betterments in future editions. He will be glad to receive further constructive criticism and suggestions from engineers, architects, contractors, teachers or others interested in the subject.

Acknowledgments

The author desires to acknowledge his indebtedness to the technical press and to the many valuable technical books and articles that have appeared on the various subjects discussed. To these he undoubtedly owes many of the ideas expressed in this book. These ideas have however been substantiated by an active personal contact with professional and business life. It has been his aim to credit the source of information whenever such source could be distinguished, for he claims little new or original except as to treatment and arrangement.

The thanks of the author are especially due to Mr. L. R. Balch for many suggestions, for aid in the preparation and proof reading of the text, and for supervision of its publication. Especial acknowledgment for valuable advice is also due to Dean F. E. Turneure and C. V. Seastone. Numerous others have made valuable suggestions which have been utilized so far as practicable; among these should be mentioned Messrs. Charles H. Paul, E. K. Shnable, H. S. R. McCurdy, H. L. Garner, F. W. Scheidenhelm and Professor C. I. Corp.

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D. W. M.

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CHAPTER I

THE ENGINEER AND HIS EDUCATION

§ 1. **The Functions of the Engineer.**—The functions of an engineer are those of a designer, a supervisor, a constructor, an operator, an investigator and an adviser. It is his duty to formulate an ideal and from it to create a reality. He must investigate conditions and determine means by which those conditions can be utilized or modified to meet certain ends; he must advise his employer as to the feasibility of the project proposed, the cost which will be entailed and the results which will be accomplished; he must develop ideas and elaborate plans; he must also consider and prescribe the methods and manner of construction; he must supervise or superintend the execution of the work and see that it is properly constructed and the ideal realized; and often, after completion, he must see that the works which have been created from his plans and under his supervision properly fulfill the functions for which they are designed.

The field of engineering work includes all of those branches of technical service and of business and professional work which have to do with the utilization of natural resources for human benefit. The function of engineering service is the adaptation of the laws and resources of nature to utilitarian purposes. It usually involves the practical consideration or the active utilization of natural conditions and natural resources through construction. It requires technical training either through practical experience and parallel study or through study followed by practical experience. Engineering in its broadest extent includes the trades, the business and the profession. The skilled artisan and mechanic and the skillful draftsman are the fundamental practical units of the engineering trade. The manufacturer, the builder and the contractor represent engineering business and are the active agents in the realization of the ideals in concrete form and frequently in the development of these ideals. The designer and estimator, the inspector and superintendent and the assistant engineer are the fundamental units of the engineering profession of which the chief and the consulting engineers are the culmination. Architecture is the application of art to engineering construction, but it is no less a branch of engineering. Names and titles are but words and have but little

significance aside from the active duties and responsibilities which a given vocation, position or business involves. All of the vocations mentioned have manifestly innumerable combinations in their actual performance and vary greatly in their relations one to another and in their relative importance. The young technical graduate may progress through various subordinate positions to the higher professional activities as chief on important engineering work, or he may through minor industrial vocation attain important positions in the industrial world. Every vocation when properly exercised is both honorable and of great importance to human welfare. Those vocations which involve great responsibility, important fiduciary relations, great skill, extended experience, high intellectual development combined with ability of intense practical application and executive and business ability of a high order, often receive the greatest rewards both in public respect and in financial returns. The positions of great responsibility, however, usually involve so great a degree of personal devotion and the sacrifice of so many of those personal pleasures of life that demand a large amount of time and energy in their enjoyment, that there are few who are willing to pay the price of the greatest professional success. All engineering success is a consequence of personality, native ability, opportunity and application; normally it may be achieved just to the extent that the individual is willing to pay the price of intelligent devotion to its attainment.

§ 2. **Engineering Relations.**—In fulfilling the duties of his vocation, whether it be in the trades, the business or the profession, the engineer comes in contact with men in almost every walk in life. The young engineer is first brought into contact with his employer and his fellows who are similarly employed. With his advancement relations will be established with customers and clients, and the work he is called upon to perform is likely to entail relations with many others. It may require the employment and supervision of workmen; it is likely to involve contact with manufacturers and contractors; it may involve contact with officials of private or public corporations, clients, lawyers, investors, bankers, and a great variety of other persons, having various interests more or less antagonistic. In his relations with the different men encountered in the various lines of engineering work, conflicts of personal opinions, personal interests and personal rights will arise which must frequently affect his course of action. A clear appreciation of the proper attitude he should assume in these various relations, and of his proper personal and professional conduct, is of great importance to his growth, development and future usefulness.

The engineer is frequently called upon to assist in the preparation of designs and plans for various structures and plants and must possess a knowledge of principles of design, strength and adaptability of materials and the various demands for strength, capacity and service that must be fulfilled. In many cases certain hazards and contingencies will be involved in both the construction and utilization of the structure or plant. These must be foreseen and considered in his design. In most cases the work, structure or plant designed and constructed must be used, maintained or operated by men of certain capacities and capabilities, depending on its location and the conditions of its installation; and the human element must therefore be duly considered throughout the engineer's entire work.

The engineer must frequently take part in the preparation of estimates, specifications and contracts. Estimating requires a knowledge of ways and means, an appreciation of the contingencies which may be encountered and a knowledge of costs of labor and material and of transportation and construction charges. The preparation of contracts and specifications requires an extended knowledge and experience; they involve certain legal and certain customary requirements, a knowledge of how work can and should be performed, and a sense of fairness and equity. Proper care in the performance of these duties will largely obviate the chances for misunderstandings and disputes, will reduce future complications and render his further duties less difficult and more satisfactory.

After the design is completed, and the plans, estimates, specifications and contract papers are prepared, arrangements for the performance of the work of construction must be made. This usually includes the preparation of advertisement, instructions to bidders, and forms of proposal. The work must be let, and if it be public work the advertisement must be placed and the letting be conducted in conformity with the laws and ordinances which prescribe the methods which must be followed in order to secure a valid and binding contract.

With the consummation of the contract, the engineer's work is only fairly begun; he must inspect, supervise or superintend the work; he must see that its reasonable requirements are carried out. In the supervision of work, the engineer becomes an arbiter with greater or less power in deciding upon the meaning of the plans and in interpreting the specifications. He must see that justice is done to both parties to the contract. He must be fair and impartial, and this in the face of the fact that he is to an extent an interested party. He is employed by

his client to supervise the work and to see that it is properly done, and is normally biased by his employment. There may also be errors, omissions or uncertainties in the plans and specifications due to his own faults or neglect and his decision may involve either an admission that his plans and specifications are not wholly adequate for their purpose, or the infliction of unjustified hardships and expense on the contractor. In all such cases every engineer owes it to himself and to his profession to see that all work of which he has charge is performed in a spirit of fairness, with malice toward none and justice toward all.

The engineer may represent the other side of the contract, that is the contractor. He may be the contractor, be employed to assist the contractor, or to take charge of the construction. Here he must possess not only technical knowledge of design but practical knowledge of construction and construction methods. His knowledge must extend to the principles of business and business methods; he should possess a knowledge of men and of the methods of handling labor; and he should possess a knowledge of business and engineering law. He must have a good understanding of the rights and privileges of both parties to a contract, of labor and of the public. In this work as in all other lines, conscientious and intelligent service will bring the greatest ultimate reward. The great railway and public service companies and most private individuals and corporations place their contracts for construction with men and firms known to be honest and dependable, and the immediate rewards for dishonest work are entirely inadequate to compensate for the tremendous discount which such work is likely to involve on all future prospects.

The young engineer may enter commercial life; he may represent the manufacturer in the sale or installation of machinery, materials or supplies. In such a position he must perform his services under a great variety of conditions and deal with many and diverse customers. It becomes important for him to familiarize himself with the product, with all its advantages and disadvantages, under all conditions of use. The temptation may come to place the product under conditions for which it is not entirely fitted and under circumstances in which it will not give satisfaction. If he yields to this temptation he adopts a shortsighted and ruinous policy. A satisfied customer is not only a permanent customer but the best possible reference. Every customer of this kind will improve and enlarge the clientage of his firm and will establish a valuable personal acquaintance and reputation which will often be a distinct advantage in future sales or in after life when he seeks other employment.

He may be called upon to install machinery and equipment and to see that in their utilization, installation or operation all difficulties are overcome and that the plants or materials are correctly used and fulfill their proper functions in a satisfactory manner. He must have initiative and ingenuity; he must be diplomatic and considerate; he must use every proper means to satisfy the individual and the public.

The engineer may be called before the court to give evidence in professional matters, and his experience and professional knowledge become of great importance. Here he must be self-possessed, clear and exact and be able to so express himself that he will convince the judge or jury not only of his professional knowledge and experience, but of his honesty and integrity as well, and this must frequently be done in the face of a cross examination intended to show that he is ignorant, incompetent and dishonest.

In giving expert evidence his attitude and his purpose should be marked by honesty, integrity and fairness. He should never lend his professional knowledge and reputation to bolster up fraud and deceit. If he is tempted to do this in order to assist the ends of his client, he should remember that such action on his part will seriously injure his reputation and limit his future usefulness.

In his diversified work the engineer may have to appear before councils and legislatures, boards of directors, meetings of stockholders, bankers and investors, and explain engineering projects. He must show the necessity and justice of required legislation, or the injustice and inadequacy of laws existing or proposed. He must show the necessity, desirability or advantageous results to be derived from certain projects or from certain improvements to works already constructed. He must show the safety of investments and the certainty of adequate returns, and requires for this work not only a fund of professional information but the ability to talk or to write clearly and convincingly in such language that his audiences will understand the matter placed before them and appreciate the truth of the proposition proposed.

The engineer may be called upon to report on undeveloped projects, and his investigations must be so complete, his data so definite, his proposed plans so well developed, his estimates so conservative, his conclusions so thoroughly founded, and his report so clear and complete that it will bear the critical examination of experts who will be called upon to review the project and pass upon its feasibility. He may be called upon to review such reports made by others in similar

lines, and large financial investments and interests which need careful consideration and protection may depend upon his report.

In reviewing such a project, he must pass not only on its possibilities as an engineering endeavor but on its probable success as a business venture. Here much more than purely engineering principles are involved: the legal rights under the state or the national laws must be considered; the probable demand for the services or product of the development must be investigated; the hazards and contingencies involved must be appreciated; the possible methods and expense of financing must be known; and no element that goes to make up a complete commercial success must be neglected if the engineer is to retain his clientage and reputation. In this work he is confronted with many opinions and influences; the promoter, anxious to finance his project; the company, desirous of floating its stocks and bonds; the manufacturer, anxious for financial assistance, each perhaps thoroughly convinced of the feasibility of his project and yet with insufficient experience or breadth of vision to take into account all of the elements of the problem. The engineer must remain unprejudiced; he must sift the wheat from the chaff, the fact from the theory, and arrive at a conclusion as to whether or not the project is feasible and the investment sound. Upon his ability to arrive at correct conclusions depends his fitness and usefulness for this important work.

The engineer is sometimes called into a semi-judicial position as appraiser or arbiter. Sometimes property interests involving millions are subject to his judicial determination. The calls to such positions are based only on a high professional standing and a reputation for fairness, honesty and integrity.

To qualify himself to properly fulfill these various functions should be the aim of every young engineer.

It is evident that the wide range of work above outlined requires not only technical knowledge and experience, but the ability for proper and clear oral and written expression; a knowledge of finances, economics, business methods, and of legal relations.

ENGINEERING EDUCATION

§ 3. **The Technical and Scientific Preparation.**—The essential aim of technical education is not so much to impart technical knowledge to the student as to furnish the training which will enable him to understand and investigate the conditions which surround a problem,

to determine the fundamental principles on which its successful solution depends, to ascertain and analyze the elements which influence or modify it, to design the structures and work needed for its successful development, and to supervise or superintend the proper construction of such structures or works and carry them to a consummation of successful and economical completion.

The amount of knowledge that can be retained in the mind at any one time is limited. The time spent in a university course, as well as the mental capacity of the student, are both too limited for the acquisition of anything more than the elements of knowledge needed by the practicing engineer. Even the practicing engineer can retain only those facts and principles that have been especially impressed on his mind by constant use. The most important acquirement therefore for the student, in or out of college, is not a detailed knowledge of engineering principles, natural laws, technical methods and detailed facts (except where such matters are needed for immediate use) but the ability to ascertain and apply the correct principles and data when needed for professional purposes.

The engineer must have a comprehensive understanding of the elements that underlie his problem and upon which its proper solution depends. He must know what and how to investigate, and how to analyze and weigh the influence of every factor involved. He must be able to see or to determine the value and effect of each element in the problem, and he must know whether the knowledge needed for these ends is available, where it is to be found, and how to acquire it. He must understand ways and means as affecting both construction and operation, and, so far as possible, he must have developed his judgment, sense of justice and equity and his common sense.

All knowledge is more or less related, and every subject bears more or less directly on every other subject. It has been said that if any man knows all that can be known of any one subject, he knows all that there is to be known of every other subject. Such a comprehensive knowledge is of course ideal and impossible of realization, but a broad foundation of many subjects is necessary to a true appreciation of any one. This is especially true of technical knowledge; and for a broad knowledge of any specialty it is both desirable and necessary that the engineer have a general knowledge at least of other specialties.

The present tendency toward specialization is, when carried far in a university course, a serious mistake if the desire is to educate engineers instead of to train skilled workmen. The ideal university for the education of the engineer is not a trade school. The education should be

largely general, and special branches should be so handled as to broaden and not narrow the student. They should be considered with relation to other special lines.

There is perhaps no more narrow man than the specialist who knows nothing of aught but his specialty; he is an unsafe guide except along his own narrow lines, for when his lines cross or run parallel with other subjects, he has no true perspective of relative importance or of relative values. Every thoughtful engineer will realize that his special knowledge and experience will influence his recommendation. Recently a proposition was under consideration that involved the installation of two pumping engines of six million gallons capacity in a location where it was undesirable to construct a boiler plant and where in consequence power had to be transmitted in some form for about a quarter of a mile. Various electrical engineers who discussed the project, uniformly recommended the use of electrical generation and transmission. After due consideration of the proposition, steam transmission, with steam pipes carefully insulated, was installed. The power consumption of this plant at full load was about half of what it would have been with an electrical plant, specially designed for the service; and at half and quarter loads, at which points the plant operated a considerable portion of the time, the saving was very much greater. The tendency of the specialist is always to advise the application of his specialty.

One of the most important elements in the instruction of the young engineer is to lead him to appreciate not only his own specialty but to give him a correct appreciation of the specialties of others. The engineer who is educated in only one specialty and has not the knowledge necessary to compare it with others, is poorly prepared for professional life, and his training will seldom give the best results to either himself or his clients.

The courses of study in engineering schools usually cover most branches of engineering in a fairly satisfactory manner when the purposes of the studies are understood and appreciated. The principles and methods on which investigation and practice must rest are fairly well developed, and the young engineer, when he leaves his technical school, is fairly well prepared to undertake the minor calculations, operations and designs in the practice of his profession. The technical graduate must not overestimate his capabilities. His education is not finished, it is only just begun. He has prepared a foundation; if it is well laid he has already accomplished much. He must now build the superstructure. This, to be successful, will require constant and stren-

uous effort. When the young engineer enters practice he still needs to acquire experience and to study, observe and investigate subjects connected with his specialty, all of which is necessary for advanced work and which he can obtain to the best advantage concomitant with the practice of his profession. For success the engineer must acquire a working knowledge of :

First: The fundamental principles of those sciences on which his work depends, and judgment in this application.

Second: Those methods and calculations which must be applied in such practice, and skill and accuracy in their use.

Third: The use of language, including the ability to prepare and present both clear and concise oral and written explanation of engineering problems.

Fourth: Business and engineering law upon which the success of engineering projects depends, and without which few correct reports, specifications or contracts can be prepared.

Fifth: Those essential principles that concern the personal relations of the engineer with his fellows, with his employers and clients, with his business associates, with labor, and with the public, and also those principles of judgment, equity and ethics upon which the highest success of every man depends.

The engineer must acquire judgment and a knowledge of men as an essential part of his education; these can come only with experience and observation.

The engineer should also acquire a correct perspective of his own capabilities and limitations. Self-knowledge is perhaps the most important knowledge, for on the one hand it will prevent the individual from attempting those things for which he is unfitted and thus eliminate failures which will result more or less seriously in their consequences, both to himself and to others; and on the other hand, it will give him the necessary confidence to undertake those things for which he is properly fitted and which will make him of the greatest value in practical life.

The tendency of technical education is rather to the detriment of judgment. If text books and instructors are considered infallible, if lectures are to be taken without question, the development of judgment is certainly not stimulated. An earnest effort should be made by the young engineer to understand the limits of theory and the point where judgment and speculation begin. The use and abuse of formulas should be appreciated, and their limitations real-

ized. Every experienced engineer recognizes the convenience of formulas but must also understand the danger of their careless application and that the application of all theory to practice must be modified by judgment in order to take into account factors often unrecognized in theoretical considerations.

§ 4. **A Knowledge of English.**—A knowledge of English, and the ability to express his meaning in clear, concise and convincing language, both oral and written, is an asset of great value to the engineer.

The ability to prepare and present with the oral or written words, the rationale of the problem to be solved and its proper solution are often as important as the ability to recognize and solve the problem. An intelligent discussion of the conditions that obtain, a proper presentation of the principles involved and a clear elucidation of the proper methods for its solution, so that each of these matters will be understood by the business or professional man by whom the problem is presented, is a most important function of education. This ability of expression can be acquired only by practice and by the constant endeavor of the engineer in the preparation of his work to place himself in the mental attitude of the one who is to hear or read the matter presented.

At almost every step the engineer is called upon to describe in clear terms, in reports, papers or specifications, both in general and in detail, the rationale of works built or proposed. The engineer is often required by his clients or superior, to examine into projects to determine the line of action necessary or desirable under the conditions that obtain, and perhaps the feasibility, nature, extent, character and cost of the construction or works which should be installed to accomplish the purpose desired. In such case he must be able to describe in clear language the conditions which he finds and the factors which will affect the proposed project, and to give in a logical manner the reasons for his recommendation concerning the character, extent and cost of the work which should be done.

When labor, material, supplies or works are to be furnished or constructed, either as a whole or in part, by others than the owner (and there are few constructions where material at least is not to be so furnished), the engineer must describe clearly and in detail the character and extent of those parts which are to be so furnished. Few designs are complete in themselves without such descriptions, and frequently the proper preparation of these descriptions or specifications is among the most important of the duties of the designer.

Proper specifications are fully as important as, and no less essential than the maps, plans and designs for the explanation of the work proposed. Frequently a design, which may be based on precedent or, partially at least, on the published plans of others, is much less difficult to prepare than the specifications which must describe in detail the materials and character of the construction, and particularly the practicable qualities of material and the methods which must be followed in their economic manufacture or construction. Even where work is to be done by the direct employment of men by the owner and not under contract, proper specifications are essential as a basis for correct estimates of cost and for the proper performance of the work.

The preparation of reports and specifications is a broad subject that touches almost every limit of human activity, and its proper performance is acquired only by long experience, careful study and detailed knowledge. Certain principles, however, can be readily acquired and understood which, if followed out, will lead the way to their successful preparation.

Material, labor, machinery or supplies to be purchased or contracted for must be ordered and an agreement more or less formal for furnishing the same must in every case be entered into. Such agreements vary from the simple form of a verbal order and acceptance for the smallest supply to the most elaborate contract and specifications for the most complex machinery or plant involving thousands of dollars. If such agreements are not properly and clearly prepared they may involve needless misunderstandings and expensive litigation. The use of good language, oral or written, is acquired only by constant study and practice and is needed by the engineer in the letters, instructions, reports, papers and specifications which he is frequently called upon to prepare. A knowledge of technical language is acquired by professional study and practical experience in special lines and is highly essential for correct technical reports, instructions, and specification writing.

§ 5. Legal Relations.—It is the duty of every citizen to so inform himself in regard to the fundamental and elementary laws under which he lives and on which his legal rights and privileges depend, that he shall have a clear conception of his own rights and privileges and those of his neighbors and business associates.

It is important for the engineer to acquire a knowledge of those fundamental principles of law which must clearly govern and control his social and business relations and his special professional activities, including the laws of contracts, in which he is often especially inter-

ested either as a principal or as an arbiter. These principles in their general relations can be readily understood but their specific application, particularly under many complex limiting conditions, becomes exceedingly difficult and calls for the advice of those who have given special study to the subject under consideration.

The engineer should be sufficiently informed concerning those legal matters which affect his duties and responsibilities to know when all ordinary legal requirements are observed in drawing up such engineering papers as may be necessary in his work and to see that the actions, attitudes and decisions of himself and his subordinates are legal and that the legal rights of his clients, business associates and of himself are properly conserved. In all cases of importance, legal advice is essential and should be obtained. Few lawyers in ordinary practice, however, possess such knowledge of engineering contracts or of the conditions of construction as is necessary in order to draw a satisfactory contract for construction work; and engineering contracts as well as technical specifications, should be prepared by the engineer and submitted to the attorney to see that the legal requirements are properly covered.

The engineer, to be successful in professional practice, must also be informed on the laws which affect his particular specialty. The municipal engineer and contractor should understand those municipal laws which affect municipal works and which both limit and control municipal activities. The hydraulic engineer should understand the laws of riparian ownership and those governing the acquiring of water rights and the construction of water power, irrigation and drainage projects, and the legal requirements of navigation, logging, fishways, etc. The mechanical engineer should understand something of patent laws and of the various other laws which affect his specialty. In each branch of engineering there are certain legal relations the knowledge of which is indispensable to successful engineering practice. Laws are so manifold that no lawyer in general practice can be thoroughly informed on all of their branches, and the engineer in practice frequently becomes better informed on those laws which affect his own specialty than does the lawyer in general practice. In matters of moment, expert legal assistance should be employed, as specialists in the law are as essential for a proper knowledge of special legal requirements as are specialists for the best practice in engineering.

§ 6. Ethical and Personal Relations.—A proper appreciation of the essential moral and ethical relations of the individual is difficult to acquire or to impart, yet there are no subjects so important or so inter-

esting as those which deal with the realities of life and the proper relationship of the engineer to his profession, to business, to the public and to his fellow men. The relations of man to man are but poorly governed by the law, and a law-abiding man may be a poor citizen and undesirable as a friend or neighbor. The personal conduct of man in the manifold and intimate relations of social, business and professional life must be governed by more generous and equitable rules than those provided by the statutes, which can furnish only regulations which will perhaps give equitable results in the majority of instances but can govern only some of the major points of contact. A man may be selfish, unfair, untruthful, narrow, egotistical, tricky, and even to a considerable degree dishonest, without fear of the law; but the individual in whom such characteristics predominate is a detriment to himself, to his friends, and to society. Every individual acquires in his youth, from his parents and intimates, a certain knowledge of moral and ethical principles which have usually a most important and lasting effect on his view of life. This knowledge is usually fundamental and needs elaboration and thoughtful consideration in its extension to the greater affairs of life. The well established principles of social business and professional ethics sometime seem disproved by the individual experiences of the young engineer who may see apparent prosperity follow a disregard of these principles. It would indeed be unfortunate if he has not been fully assured that such results are only apparent and that the greatest and best success can come only with the highest conception of duty.

Most practicing engineers and business men recognize the fact that a true appreciation of ethical relations is fully as important for success as technical knowledge or business ability; that irrespective of morals or religion, honesty is in reality the best policy and must be exercised in all social, business and professional relations in its broadest sense. To do as he would be done by, is the simplest, broadest and the most complete ethical standard for the individual. A sincere regard for both the legal and the moral rights of others, whether associate, employer, client, workman, contractor, competitor or the public, is a necessary attribute to the greatest success. All honest and conscientious effort toward personal advancement is commendable, but the rights of others must be consistently observed. The establishment of a personal, business or professional reputation for honesty and dependability is a greater asset than any immediate profit from unethical actions. These conclusions have stood the test of long practical experience in business and professional life.

As responsibilities increase, as fiduciary relations become established, as the work of the engineer attains a higher professional character, there becomes involved not only conscientious honest and energetic effort toward personal professional advancement, but also obligations toward the profession and toward humanity, even at the sacrifice of personal interest.

The term "professions" includes those callings which involve in their practice high ideals, great energy, distinguished ability, correct and logical thought by means of which effective results are obtained, through efficient application of technical knowledge and proper organization. Such callings also involve a high conception of personal honor and personal obligation not only toward all with whom the practitioner comes in personal contact but toward the profession, the state, the nation, and toward humanity.

The engineer must understand therefore, not only the elements necessary for personal success but also those requirements necessary for the realization of the higher ideals of professional success.

LITERATURE

Addresses to Engineering Students. Edited by Waddell & Harrington. Published by the authors, Kansas City, Mo.

* Limitations of Efficiency in Engineering Education, by Professor George F. Swain. Eng. Rec., Vol. 62, p. 712.

* The Profession of Engineer, by Waddell & Harrington.

* Two Kinds of Education for Engineers, by Dean J. B. Johnson.

* Engineering Education, by Prof. Frank P. McKibben.

* Hints to Students on the Education of an Engineer, by Dr. Ira O. Baker.

* The College Graduate as an Engineer, by Dr. Alex. C. Humphreys.

* The Study of Engineering, by Prof. William H. Burr.

* The Making of an Engineer, by M. J. Riggs, C. E.

* The Twentieth Century Engineer, by Prof. Henry S. Carhart.

* The Relations of Civil Engineering to other Branches of Science, by Dr. J. A. L. Waddell.

* College Training of Electrical Engineers, by Prof. Arthur C. Scott.

* The Present Status of the Engineering Profession and How it may be Improved, by Dr. J. A. L. Waddell.

* Criticism of the Engineering Schools, by Prof. Dugald C. Jackson.

* Last Words to the Civil Engineering Seniors, by Dr. Ira O. Baker.

* Higher Education for Civil Engineers, by Dr. J. A. L. Waddell.

Engineering as a Profession, by W. J. Frances, Canadian Engineer, Vol. 25, p. 685.

* Addresses to Engineering Students. Published by Waddell and Harrington, Kansas City, Mo.

The Civil Engineers, by B. W. Kennedy. Eng. Rec. Vol. 54, p. 582.

The Relation of Electrical Engineer to Other Professions, by Gano Dunn. Presidential address, Am. Inst., E. E. 1912. Trans. Am. Inst., E. E. See also Eng. News, Vol. 68, p. 476.

Engineering as a Vocation, by Earnest McCullough, Donnaly & Co., New York.

Engineering as a Career. Edited by F. H. Newell and C. E. Drayer. Van Nostrand Co., New York.

The Status and Professional Relations of the Engineer Discussion before the American Institute of Consulting Engineers. Pamphlet. Office of Secretary, 10 Park Ave., New York.

Plea for the Broader Education of the Chemical Engineer, by Clifford Richardson. Eng. Rec. Vol., 57, p. 18.

Electrical Engineering Education, by Chas. P. Steinmetz. Electrical Review, Vol. 52, p. 182. See also Trans. Am. Inst. E. E., June, August and September, 1902.

The Engineering Graduate and the World, by Dean Charles H. Benjamin. Eng. News, Vol. 67, p. 1084.

Men Wanted, by Charles Whiting Baker. Eng. News, Vol. 67, p. 1178.

Engineering Service and the "Practical Man" in Engineering, by Antonio Lans. Eng. News, Vol. 62, p. 192.

The Influence of Pure Science in Engineering, by Sir J. J. Thompson. Eng. Rec. Vol. 62, p. 679.

The Work of the Engineer, by B. W. Kennedy. Eng. News, Vol. 56, p. 563.

Contemporary Technical Education, by John R. Freeman. Jour. Assoc. Eng. Soc. October, 1904, p. 507.

Status of the Civil Engineer's Profession in the United States. Annual Address of President of Am. Soc., C. E. 1909. By Onward Bates Trans. Am. Soc. C. E. Vol. 64, p. 567.

See also Eng. Rec. Vol. 60, p. 34.

Presidential Address of Sir Alex B. W. Kennedy. The engineer, his relation to science, art, nature, law, commercial, professional and industrial life. Inst. of Civ. Engrs. Nov. 6, 1906.

Professional Ideals of the 20th Century. Address by Pres. Hadley of Yale. Eng. Rec. Apr. 20, 1907.

Presidential Address to North East Coast Institution of Engrs. and Ship Bldrs., W. H. Dugdale. Summary of Engineering from earliest times showing value of technical institutions. Trans. N. E. Coast Inst., Engrs. and Ship Bldrs., Jan. 1907.

The Training of the Electrical Engineer by Dr. Louis Bell, Discusses qualities needed and means of acquiring them, for success in Electrical Engineering. Cassier's Mag. Jan. 1905.

Proper qualifications of Electrical Engineering School Graduates from the Manufacturers Standpoint, L. A. Osborne. Discusses qualities lacking in the average graduate. Trans. Am. Inst. E. E. July 1903.

Engineers Must Learn to Sell Their Ability. Discusses desirability of teaching how to write and speak convincingly, and the value of ethics. Editorial. Eng. Rec. July 15, 1916, p. 85.

CHAPTER II

SUCCESS IN THE ENGINEERING PROFESSION

§ 7. **Personal Success.**—Success in life, like success in the construction of an engineering structure, requires a good and a proper foundation on which to build. Success is measured by many men in many ways. The best success is not measured by great wealth or great power nor by the greatest amount of idle pleasure, for the pursuit of any of these single purposes does not result in the greatest happiness which is perhaps the truest measure of the greatest individual success.

The greatest success results from a well balanced life and should usually include:

First: Suitable friends and family relations; for the greatest success does not come with solitude.

Second: Sufficient income for the comfort of the individual, his family and dependants, and to permit him to help those philanthropic movements in which all should take part.

Third: A good personal, professional and business reputation in his life work.

Fourth: The respect of his friends and associates.

Fifth: Self-respect or the personal approval of his own conscience, resulting from the proper observance of personal religious and ethical convictions.

Whatever may be the ideal of the individual, if it be worthy of the name of success, its attributes are health, native ability, character, education, experience and opportunity. Each is partially independent and partially dependent on individual effort, and each can be improved and strengthened by the exercise of care, perseverance and energy.

Character, while partially hereditary, is more largely due to the influence of family and associates, and to education and personal cultivation. That the age and thought of the times largely control character is undoubtedly true, yet no age or nation has been so degenerate that it has not developed some men of high ideals and of character creditable in any age. No high professional standing is ever attained without properly developed character; it is like the internal mechanism of an important machine, unseen but essential to the proper and correct exercise of its highest functions. It is the

main spring of the best success and is susceptible of great modification and improvement by individual effort.

No great success is possible without health. Ill health draws the attention of the mind to the condition of the body at the expense of the capacity for concentrated thought, affects the ability for energetic effort and weakens the power of resistance and personal capacity. Clean living, healthful exercise and mental relaxation are therefore not only desirable but essential for both personal, business and professional success. A knowledge of personal and public hygiene and sanitary requirements is necessary not only for their influence on personal health but also on account of the engineer's control of the health of others in his public relations and in his private relations in the factory and in the field.

The degree of native ability possessed by the individual is undoubtedly a considerable element of success if properly utilized and developed. It cannot take the place of hard and conscientious work and continuous effort. Most so-called "men of genius" will admit that their success is due more to hard work and continuous effort than to native ability. Greater success is due to the personal exercise of will power that concentrates the efforts on the end in view and utilizes such ability as is possessed by the individual than to the half cultivated spasmodic exercise of so-called genius. The individual who possesses both great native ability and the ability for sustained concentrated effort has opportunities of high order. In all cases, the development of ability is dependent to a large degree on individual endeavor.

Education and experience are to a considerable degree the results of opportunity, but they are still more largely acquired through individual exertion. The lack of college or university opportunities is no bar to the individual who is willing to exert continuous and unremitting effort in the acquisition of an education. The schools and instructors are an aid, not a necessity; and such aids should be utilized when available, but they can be dispensed with when necessity demands, if replaced by energetic, vigorous and forceful application.

Experience is best acquired by personal observation, but the recorded practice of others is a source not to be neglected.

Opportunity may freely come to some, but it is created by many. The lower rounds of the professional ladder are congested with throngs of young men half educated and half prepared, clamor-

ing for opportunity, while the higher positions for which they are unsuited are often only poorly filled and waiting for the proper person.

There are few professional lines in which an able, well educated, well informed man of high character will not find opportunity waiting and anxious for his coming. Strenuous, unremitting labor and continuous, conscientious effort are the prices of success.

§ 8. Factors of Success Must Be Recognized.—The attributes described in Section 7 must be both acquired and properly exercised; they must develop in the individual those certain habits of industry and traits of character which are demanded of professional and business men by their employers, clients and associates and without which the individual will be at a great disadvantage in the practical affairs of life. The successful solution of any problem depends on both a comprehensive knowledge and a proper application of all of the factors on which the solution depends. In order therefore to succeed in the various problems of professional and business life it is no less essential that all of the factors of success shall be duly appreciated and given the proportionate weight which their importance demands.

Much might be written on any of many factors of success, but only a brief discussion on some of the most important seems warranted. Common sense and judgment must extend the list and supply further details. If a limited discussion is not sufficient to convince a man of the essential nature of the characteristics discussed, further elaboration would result only in a waste of both space and time. The man who will win success will be able to recognize its essential elements without extended discussion.

§ 9. Opinions of the Engineering Profession.—For some years a joint committee on engineering education from the national technical societies of the United States has been investigating engineering education, and by an arrangement with the Carnegie Foundation for the Advancement of Teaching, a detailed investigation has been undertaken to determine the qualifications necessary for success in engineering work. In the spring of 1915 letters were sent to the members of all of the national technical societies requesting individual opinions on the essential characteristics of an engineer. A report* was made in the spring of 1916 as a result of this investigation, in which the essential factors were summarized into six groups which were numbered in the order of their importance as determined by the frequency of their occurrence in about 1,500 replies. On the basis of this preliminary work

* Report by C. R. Mann. Proc. Am. Soc. C. E. Feb. 1916.

a new letter was sent out to the members of the society asking for further consideration of the six characteristic groups previously outlined. To this letter 5,441 replies were received sufficiently definite for classification. From these letters the most probable values of the relative importance of these groups of qualities were computed with the following results, which seemed to indicate a rather definite ideal of the professional engineer as to the characteristics necessary for the greatest success:*

Revised and Original Ratings

	Revised	Original
Character, integrity, responsibility, resourcefulness, initiative	24.0	41.0
Judgment, common sense, scientific attitude, perspective	19.5	17.5
Efficiency, thoroughness, accuracy, industry	16.5	14.5
Understanding of men, executive ability.....	15.0	14.0
	—— 75	—— 87
Knowledge of fundamentals ..	15.0	7.0
Technique of practice and of business.....	10.0	6.0
	—— 25	—— 13
	100	100

It must not be understood that any single arrangement of these six groups actually indicates the views of professional men as to the essential characteristics of an engineer for each and every position, for it is manifest that each individual should have the essential characteristics developed to the greatest advantage for the particular position which he occupies. Each man must be capable of a proper performance of his duties, and his lack of any essential characteristics is necessarily fatal to his success.

The metals used in engineering construction are in most cases alloys and consist of a combination of various elements some of which are essential and some of which are considered as impurities. Nevertheless each element whatever its character and amount has a particular influence on the character of the alloys. If any one is missing it may change the entire characteristics of the alloy and make it unfit for some particular use. For the greatest usefulness in any particular place, each element must be present to the extent needed. In the same manner a man may be useless in an engineering position, even though his character, judgment, efficiency and understanding of men may be highly developed, unless he has a proper knowledge of the fundamentals of engineering science and the technic of practice; and yet in all professional positions which involve fiduciary relations (and there are

* What is an Engineer. C. R. Mann. Eng. Rec. Vol. 74, p. 10.

practically no positions which do not) there can be no doubt that character, judgment, efficiency and understanding of men are of much greater relative importance in the attainment of the greatest professional success, if it can be stated that one essential is of greater importance than another where all are absolutely necessary in some degree.

§ 10. **Judgment.**—The few years spent in a technical school cannot give a profound knowledge of any of the subjects studied. The fundamental principles of those sciences on which practice is based must be acquired, but these principles must usually be further investigated and their relation to practical things more fully determined when the engineer comes to apply them to the actual work of design and construction. Methods of investigation and of calculation must also be further considered and judgment and skill in their use acquired when their application to concrete problems becomes important. In the class room the conditions of the problem are usually distinctly stated. The factors that enter into it are definitely assumed. The theory that applies to these conditions is before the student. The application of the principles and the solution of the problem under such conditions are not difficult because the uncertainties are eliminated. In the field the circumstances are very different. Here the engineer must determine for himself the correctness of the theory which he applies; he must determine the factors which actually enter into the problem and he must be certain that there are no other considerations which will affect it and render the theory inapplicable or the solution incorrect. Accuracy, thoroughness and speed become important in the field. On these functions depend not only the personal success or failure, which is important to the individual, but often the success or failure of the engineering work which may involve lasting benefits or loss of both life and property.

The very keystone of successful engineering practice is judgment. The development of judgment requires personal investigation, personal consideration and personal conclusions, and should be based on a well balanced appreciation of both theory and practice. In the development of judgment the dicta of instructors, the statements of text books, and the opinions and conclusions of others must be questioned, and can be accepted only when they satisfy the fullest inquiry and analysis. In other words, the engineer, in order to develop his judgment, must learn to think for himself, to form and hold opinions of his own, and to base those opinions on a substantial, comprehensive and thoughtful consideration of both theoretical principles and practical results.

Judgment may be based on practical experience and is then applicable within the limits of that experience. When however judgment is based on a correct theory which has been substantiated by a wide range of practical experience, it is capable of being applied to a much wider field than when based on practice only. It is also apparent that judgment must also be based on a correct perspective of the individual's personal attributes and aptitudes, for if the individual deceives himself through his own personal traits his judgment will be unsound.

§ 11. **Self Knowledge.**—Students and others in college or out who have in a large measure pursued their studies and investigations more or less independently have small opportunity to compare their own ability with that of others who are proficient in the same line. No man has a fair opportunity for self-knowledge until he is able to compare himself with others in the real problems of business or professional work. It is vital that the individual be able properly to estimate his own abilities in order that he may miss no opportunity which he is justified in undertaking, and in order that he shall also avoid undertaking those things for which he is not qualified. There is perhaps no more difficult matter than adequate self-judgment. On the one hand a large proportion of individuals naturally over-estimate their own abilities, while on the other hand a considerable percentage fear to undertake new adventures for which they have received reasonably satisfactory training. Over confidence and an over estimate of individual ability will result in failures which are always embarrassing and sometimes seriously limiting to future opportunities. One who has shown false judgment in matters of moment commonly loses the confidence of those who have hitherto trusted him, and he is seldom entrusted with additional problems of a similar nature until he has overcome by long successful service the record of his failures.

A lack of the appreciation of one's individual capacity will lead to the loss of opportunities, which is also serious. People have confidence in those who have confidence in themselves until they learn that the confidence is misplaced, and opportunities come to the greatest extent to those who believe and know they can accomplish those things which they undertake. A man is foolish who undertakes those things for which his knowledge and experience have not fitted him, for the chances of success under such conditions are too remote and the results of failure are too serious. No less foolish is the man who fears to undertake things for which his education and experience have given him ample preparation and who, on account of the lack of self-confidence, is un-

willing to attempt those undertakings for which he has been amply prepared. The successful engineer must rightly weigh and appreciate his own limitations and must recognize his personal deficiencies and the meagreness of his knowledge; and he must know that success is dependent on the proper use of his best ability and upon thorough, hard, conscientious and intelligent work.

§ 12. **Personal Bias.**—That all men are to a greater or less degree biased in their judgment of themselves and of others and of all problems and conditions with which they come in contact is established by common experience. This bias is due to their individuality, their association, their local and individual experience, their education and special knowledge, and their personal interests. That this bias is possessed by others and injuriously affects their judgment is easily recognized. It is more difficult for the individual to recognize such bias in himself. It is however most important for the engineer to recognize his own bias and to provide for it by elimination so far as possible, and by the same factors of safety which he applies to other uncertainties. To acquire this knowledge is perhaps the most difficult in the practical education of the engineer.

Bias of Special Knowledge.—Special knowledge and a special experience in a limited field of engineering, unless accompanied by a broad consideration and a considerable knowledge of collateral subjects, are apt to involve a prejudice or bias in favor of the application of such special means to the solution of all problems to which such means can be applied. The specialist naturally appreciates the full value of his specialty and the advantages that accrue from its application. Normally, he is less informed in other special methods of solution of his problems, and is apt therefore to give undue weight to the advantages which he knows his own specialty to possess. The hydraulic engineer is apt to overrate the advantages of water power and to underrate the contingencies of its construction and maintenance. The steam engineer is apt to over estimate the value of the use of steam power in the solution of all power problems, and the electrical engineer, recognizing the advantages of electrical generation and transmission is apt to consider only electrical methods in power applications. In each case the advantages of other methods may be overlooked and the problem solved on individual preference and information, and not by the method which would prove the most advantageous if all conditions and methods were fully weighed and considered.

In the correct solution of any problem, all of the methods by which

it can be solved are deserving of the fullest and most careful investigation and consideration, for only by such means can the best solution be found; and the engineer who is desirous of securing the best and most economical solution of the problem entrusted to him must give the most careful consideration to those methods with which he is least familiar, for only by so doing can he hope to accomplish the best results.

Bias of Personal Experience.—Personal experience should give the engineer his most useful and exact knowledge, provided such experience is properly considered and digested. The fact that the knowledge so acquired is the most exact and valuable in his possession is apt to give it undue importance in the solution of other problems with which he has to deal. A successful engineering achievement, the product of ideas well matured, and of plans carefully prepared and well executed, which has resulted in the creditable solution of an intricate problem, may rightly lead to the future application of similar methods and designs to problems of a similar nature. Frequently, however, there is a tendency for the successful designer to endeavor to adjust the conditions which prevail in a new problem so that they may be solved by the methods previously successfully adopted rather than to adjust the plans to meet the conditions as they exist. This tendency frequently results from a natural indolence to plan and adapt new methods to a problem where a successful solution, which has stood the test of practice, is immediately available; and in many cases, the plans of a professional man bear evidence in themselves by the possession of certain common features of the source of their origin and the disinclination to consider each problem anew on its individual merits.

Bias of Local Experience.—The normal conditions which obtain in any locality must of necessity modify the successful solution of every local engineering problem. A professional man who has successfully met the various problems as necessarily modified by local conditions within the range of his practice, has therefore to readjust his ideas and to modify his plans whenever he is called upon to solve a problem under circumstances where the local conditions differ to any considerable extent. For example, the flow of streams differs radically not only on account of the difference in rainfall on the different drainage areas, but even more largely on account of the geological and topographical conditions; and the engineer who has given special attention to one stream must use especial care when he considers construction which is to be carried out on another stream for which the conditions of flow may be radically different.

In the matter of electrical supply for light and power, the demand per capita varies greatly in different parts of the same country and in cities of various sizes, even closely adjoining. Local factors greatly affect the cost at which work can be done. In the larger cities, the existence of labor unions, which usually involve higher wages and shorter hours, and frequently more inefficient service, together with the extra cost involved by street obstructions and other similar factors, ordinarily greatly increase the cost of work over that for which similar work could be done in communities where the market for labor is not modified by such conditions, where traffic and obstructions are less serious, and where many other conditions are favorable to cheaper construction. It is a common observation that men familiar with only one set of these different conditions commonly fail to agree on the cost at which work can be done in some third community where neither has had actual experience. The city contractor who occasionally bids on work in the smaller communities of the country is usually unsuccessful as his experience with the high prices of the larger community prejudices his judgment; and the contractor familiar with the work in the smaller communities commonly learns by dear experience the extra cost involved when he attempts to transfer his operations to the larger cities. These difficulties can be overcome by freeing the mind of purely local influences and by a detailed determination and consideration of the new conditions.

Bias of Personal Interest.—It is important that the engineer should free himself as far as possible from the bias of personal interest which is a constant menace to sound judgment. No matter how conscientious a man may be or how much he may endeavor to arrive at judgments which are thoroughly sound, he is constantly in danger of not attaining the results desired if his personal interests are in any way involved.

The engineer who is out of employment may, on account of his necessities, be greatly tempted to accept employment or commissions which are entirely beyond his experience or ability. Reports on special projects are often unduly optimistic for the reason that the engineer making the report is unconsciously influenced by the fact that a favorable report will mean the prosecution of the project and his employment in its design and construction.

An engineer having a patent for some methods or process by which a problem has been satisfactorily solved is constantly in danger of advocating this method, when it is at all applicable, and this from no dis-

honest motive but on account of the fact that he has become so impressed with his favorite plan that he gives it a value to which it is seldom entitled. It is essential therefore that the individual endeavor to eliminate so far as possible any personal interest which he may have in the problem, except the interest of its correct solution. If its solution on certain lines involves a profit to himself, such profit can be of only the most temporary and unsatisfactory character if it does not also involve the greatest possible success.

Bias of Association.—Almost every problem is capable of a variety of solutions although there is only one solution that can be the best when all things and matters are considered. Almost every question can be regarded from several points of view, and the correct answer is not always clear or apparent. Association will normally establish the point of view from which the individual will consider any question which is called to his attention. The most common exercise of this tendency is found in the unfair treatment of contractors by engineers who are employed to plan and supervise the construction of engineering works. There is a constant tendency to inflict unjust requirements, and to require unwarranted expense especially in meeting contingencies which have not been anticipated by either party and which therefore could not have been included in the contract. The engineer is too apt to see matters entirely from the view point of his client and to fail to exercise that impartial judicial attitude that his professional position demands.

In work of appraisal where a municipal corporation contemplates the acquisition of the property of a public utility, the engineer is almost certain to assume the point of view which is most favorable to the side which he is called upon to represent. This may not result from any desire on his part to be unfair or biased, but is normally what is to be expected from the action of the human mind. Those who have served as chairman on boards of appraisal to which they have been selected by the agreement of both sides, and have consequently been unbiased on account of their appointment, have frequently observed the radical differences of opinion which have obtained among their colleagues whom they knew to be men of great ability and of the highest integrity.

Most men who have engaged in this class of work, after the completion of the appraisal and after the heat of the argument has faded away, recognize the same tendency in some of the ideas and opinions which they have previously held and which at the time had their com-

plete endorsement and were the results of their most profound convictions. A peculiar result of this normal attitude, which is often appreciated by men engaged in such work, is that when they are endeavoring to be entirely fair and equitable in their findings and appreciate their own inclination to bias in these matters, there is a proneness at times to rather overdue the matter and to consent to findings that are more or less unfair to those whom they represent. This is usually, however, a minor matter and does not vitiate the general proposition that in the main the tendency is to unfairly favor the client, but it emphasizes the fact that the fair-minded man is not always able to bring in an equitable finding in the face of his association and the personal proclivities of those by whom he was selected.

The same tendencies are more fully emphasized by the expert witness. There the personal bias of the witness is often accentuated by the endeavor of the other side to confuse or confound the opinions expressed. In some cases these idiosyncrasies are so pronounced and are carried to such an extent as to even give the appearance of dishonest intentions, to which they are sometimes so closely related as to be almost indistinguishable and may grade from mere prejudice to actual dishonesty in many lines of engineering work.

§ 13. **Personality.**—The personality of the individual is of great importance and has a marked effect on his advancement. Good appearance, good address, proper self-confidence and self-respect, the evidences of intelligence and energy, the ability of proper expression, a proper consideration of the feelings and rights of others, mark the man for higher position and better things. Great ability and high technical knowledge and training may hold respect though the personality is unfavorable, but such respect is given not because of such personality but in spite of it.

It is unfortunate that many young men who enter technical work acquire the idea, that as engineering sometimes involves the utilization of great strength and energy in pioneer investigations and construction, its practitioners should be not only strong and energetic but also rough and rugged, and that personal refinement is a thing rather to be discouraged than sought. No greater error is possible.

The rough, strong, energetic character who ignores all personal discomforts either of himself or of others and drives construction work to successful completion in the face of great difficulties may be admired for the results which he achieves in spite of his roughness and disregard of dangers and discomforts. Such characters are bred in

the construction camp in contact with hardship, ignorant labor and unfortunate frontier conditions, and they may be an important element in such classes of work; but they are in no way representative of the ideals of the engineering profession.

The social amenities of life, the polish of society, are not signs of efficiency but they are important means of lubricating business and professional relations.

The field executive who is actually constructing engineering works is the ideal of the average young engineer, and is his idea of the personification of the engineering profession. He fails to recognize that back of this, behind the actual construction work, is the brain that conceives and the mind that directs.

Personal Appearance.—Personal appearance is also worthy of consideration, for impressions are based on the appearance, which is strongly indicative of character. Appearance is not simply a matter of dress but of personal attitude as well. A man should not be too modest or diffident, nor loud, overbold and familiar, but he should be quiet, confident, frank and business like. In dress he should be neat but not fastidious. He should endeavor to be inconspicuous, for conspicuous dress usually shows unfortunate idiosyncrasies which need to be eliminated. The busy man has little time to give to the question of dress, but neatness and modest, quiet apparel, suitable to the work or position occupied, are indications of a well and properly balanced man.

Punctuality.—Lack of punctuality is due to heedlessness, carelessness, lack of consideration, or conceit, any one of which is equally objectional and the possession of which is a serious detriment to the individual's prospects. Punctuality is an essential qualification for success. An employee who is habitually tardy not only robs his employer of the time for which he is receiving compensation but frequently causes a consequent loss of the time of the employer or others whose services are of much greater value. A record for habitual tardiness is most unfortunate for it is a serious handicap for both present and future employment.

In professional life, the man who habitually disregards the convenience of his associates and causes the loss of their time and patience by the lack of punctuality in meeting appointments shows the lack of a due consideration of the rights of others and will soon find that he is eliminated from such conferences whenever possible. He will lose much of the consideration and many of the opportunities which are essential to the best professional success.

Attention to Business—Not only should the employee be punctual in his arrival at his place of business but he should also devote his attention to his legitimate work during the hours set aside for that purpose. Office hours are comparatively brief, and arrangements for evening pleasures, a good story, the morning paper, the passing crowd and many other attractions which may catch the attention during business hours should be studiously avoided. They can well wait until the hours of work are passed, and if given attention during the time for business will require not only time which should rightly belong to other things, but will weaken the ability to concentrate the attention on the matter to which the time of the employee should be devoted. Willingness and cordial execution of orders and requests tend greatly towards promotion.

Concentration—The ability to concentrate one's attention on the immediate problem for consideration is a primary requisite for success and is a matter to which the young engineer should give his immediate attention and his best endeavor. This characteristic should be developed early in life for it is fundamental to the accomplishment of any really valuable results in scholastic or business life. It should be inculcated in the pupils of the common schools, impressed on the students of the college and university, and practiced by the individual in every phase of his later life. The ability to concentrate results in the greatest saving of time in school, in college, in the laboratory, the office, the factory and the field. The man who can concentrate his attention on a problem will accomplish his work accurately and rapidly and will therefore be of greatest value to himself and to his employer. The ability to drop a problem in order to receive directions, or on account of various other interruptions which may occur, and to at once take it up at the point where it is dropped, without loss of time or the reconsideration of the phases already examined, will result in the maximum conservation of time and the highest efficiency.

The student often acquires the habit of concentration in solitude, and finds in the office, the factory or the field his attention distracted from his work by the confusion due to the presence of others and the work which is going on parallel with his own. He must train himself to ignore all that is around him and to keep his mind and attention strictly on his own particular work; and when he is able to accomplish this, he will be surprised at the amount he can accomplish and at the rapid flight of time. The individual should learn to put his whole mind and energy on whatever he is doing to the exclusion of all else, whether

he be employed in working, playing or in sleeping. The man who cannot do his whole duty during his working hours because of thinking of the pleasure which awaits him, who cannot enjoy the present pleasures because his mind constantly reverts to his work, or who cannot properly sleep because of the business matters which constantly engross his thoughts, will make little progress in his work and is in danger of business failure or mental collapse.

The day's work should receive undivided attention, but in after hours the worries and difficulties of the day should be entirely laid aside and the time given to healthful recreation or to other matters of a beneficial nature. A sufficient time must be given to undisturbed sleep.

Relaxation from arduous and continuous effort is essential to health, but a change in occupation is frequently as advantageous as an entire cessation from labor. Many men have found the pursuit of some science, collateral to their business, or in which they took a particular interest, both stimulating and restful, and such pursuit has sometimes elevated its votary to higher things. The man who wastes time wastes opportunities. Relaxation should be a means, not an end. A young man who was playing billiards with Herbert Spencer, after running up a remarkable score asked Mr. Spencer's opinion of his play. "Young man," the philosopher replied, "I regard a slight proficiency in billiards an accomplishment which every man might well enjoy, but such proficiency as you show bespeaks an ill-spent youth." There have been men who have seriously impaired their health by too constant application and by over work. They are small in number, however, and the danger of such excess is not great. There are more professional men who rust out than who wear out.

Collaboration—The individual should train himself to work in harmony with such associates as he may meet in any organization. He should eschew petty jealousies, fault finding and gossip. He should both avoid giving offense by careless words or actions and should endeavor to overlook and ignore thoughtless speech or action on the part of others.

A peevish or irritable disposition, and the habit of using sharp, bitter or inconsiderate language, unfits a man for successful association with others and deprives him of much of his usefulness, and consequently of the greatest value to himself. The habit of constantly taking or giving offense, for the two traits are usually possessed in common, is a serious handicap and will often eliminate the unfortunate

possessor from important opportunities. Such a habit is so despicable that it frequently becomes unbearable and the greatest ability cannot compensate for the undesirable quality.

Petty jealousy is equally reprehensible. The man who cannot rejoice at the advancement of others but feels personally aggrieved because he has not received preferment will usually impede his own progress.

It is frequently true that promotion depends both on ability and individuality, and failure to secure the promotion which seems honestly due should result in a serious consideration on the part of the individual of his own deficiencies in personal character, personal effort or personal ability. It should be a spur to greatest effort toward individual improvement for in general it is true that the man best fitted for a given position will be selected to fill it, for only in this way can the best results be obtained.

§ 14. **Professional Improvement.**—In order to grow and to develop, the engineer must acquaint himself with the ideas and activities of others who are working in his own field. It is therefore essential that the young engineer should mingle with his fellows and compare his ideas with those of others in professional lines. He should early associate himself with those technical societies before which those problems of engineering in which he is particularly or generally interested, are discussed and he should at least listen to or read the papers and discussions of others both in the society proceedings and the technical papers in order that he may gain a proper idea of current engineering and practice and judge and appreciate the limitations of his own ability. When he can contribute to the information by paper or discussion it will be distinctly to his own advantage to do so for in so doing he will strengthen his own knowledge and abilities and subject his work and conclusions to the criticism of others and frequently thereby correct his misconception. For this purpose the minor state and local engineering societies are of great advantage, for before such societies matters of local and personal interest can be discussed to advantage.

A good paper properly prepared which describes the development and successful completion of new work and the experiences resulting therefrom, or coordinates the experience gathered from extensive observation and study, not only improves and intensifies his own conception of the problem, but establishes a record of his work, extends his acquaintance, and is of such direct professional benefit to the writer as the importance of the matter and the general excellence of its treat-

ment may determine. In the preparation of such papers due acknowledgment should be made of personal indebtedness to others for data received, information furnished or the use of illustrations and suggestions in the preparation of papers and technical articles. Piracy of ideas or plagiarism should be studiously avoided, and a kindly consideration of the rights and feelings of others and a proper recognition of their aid and courtesy are highly desirable.

The young engineer should constantly seek information on the various phases of engineering work with which he comes in contact, for otherwise the opportunity for acquiring special information and special experience with its consequent advantages will pass unnoticed. Opportunity seldom announces its advent with trumpets, and when so announced is most likely to prove a pitfall instead. Opportunities to acquire specialized information that is greatly needed in the engineering and business world lie on every hand and await the mind that can appreciate, develop and apply them to practical needs. Those that are the most obvious and easily developed commonly offer the greatest competition and the lesser emoluments. Those that are the most obscure and difficult frequently return the greatest rewards for the intelligence and devotion which their successful development demands.

To see the opportunity, to develop it systematically, to apply it intelligently, and to apprehend from its conquest a well earned success, requires keen foresight, an appreciation of the present and future trend of events and both general and special knowledge and experience. There is scarcely a line of professional work in which radical improvements are not both desirable and possible. New conditions are constantly developing that old practice is inadequate to satisfy. New lines and new specialties are in constant demand. The man who can see these needs before they are fully recognized and offer an effective method for their satisfactory fulfillment, will usually command a suitable reward. The successful solution of a problem or the completion of a well considered and commendable design for any engineering work should not limit the efforts of the engineer to improve his methods or designs when similar problems or similar works are under consideration. There are scarcely two problems of the same kind that can be solved to the greatest advantage in entirely the same manner. Every problem is surrounded by its individual conditions that differ to a greater or lesser extent and should modify any plan which is devised for its solution. There is scarcely a plant installed or a building or other structure erected but that the designer, if he gives it careful and

thorough consideration, may not find methods of betterment if he were called again to solve the same problem. This being the case, it is evident that each new problem should meet with a more intelligent solution; the new factors that are present should modify the original plans; and the betterments which were possible in the first construction should here be adopted to advantage and probably still further elaborated.

There is nothing stationary in nature, and the individual in his profession or business relations is either advancing or deteriorating. As long as he can see ways and means by which his work can be improved, as long as he finds it necessary and desirable to study and investigate and to improve his knowledge, his ideals and their practical expression, so long is the engineer growing and improving and his value is increasing; but as soon as he is satisfied with his work and believes no further improvement to be possible, his progress has ceased and, at least in comparison with the normal advancement in professional work, he is losing ground, and unless he acquires an entirely different attitude, his usefulness will soon be a thing of the past.

Literature

Personal Power, by Keith J. Thomas. Funk & Wagnalls Co., New York.

* The Durable Satisfaction of Life, by Charles W. Eliot.

* The Necessity for Individual Engineering Libraries and for Continuing Study after Graduation, by John L. Harrington.

* The Educational Value of the Technical Press with Special Reference to Engineering News, by Harwood Frost.

* Business Training for the Engineer, by Dr. Alex C. Humphreys.

* The Practical Engineer, by Onward Bates.

* Ambition, by Winder E. Goldsborough.

* Knowledge and Action, by Walter C. Kerr.

* The Next Step, by Walter C. Kerr.

* Study Men, by John F. Hayford.

* Success, by Dr. M. E. Cooley.

* Some of the Essentials of Success, by Dr. Chas. Sumner Howe.

* Address to Engineering Students. Edited and Published by Waddell & Harrington, Kansas City, Missouri.

CHAPTER III.

THE ENGINEER AT WORK

§ 15. **Purposes and Results of Technical Training.**—It is not the aim of professional schools to turn out professional men. The limited time spent in the technical school and the object sought do not warrant such a purpose. The object of professional training of technical men has already been considered (see Sec. 5) and the necessity of developing judgment, accuracy and speed by the practical application of such training to actual work has also been discussed (see Sec. 9). It is evident to all practicing engineers and architects that the subjects studied in the schools can become of practical value to the professional man only through their actual application under many conditions and in many places. Practical knowledge may be developed to a considerable extent in a trade school for its field is limited to narrow lines, but in a professional school the field is so broad that the opportunities for such development are small and real professional knowledge must be gained or at least improved largely by practical experience. If the student has become thoroughly interested in the profession which he has chosen, if he has acquired the ability to apply himself to work and study, if he has attained a good conception of the manner in which and the source from which professional information can be obtained, and has gained at least limited facilities in the use of those elementary features of practice on which his early employment will probably depend he has done all that can reasonably be expected in a graduate of a technical school. He has not become a professional man, but he has acquired a capacity which when properly exercised will assure him the professional standing which his abilities and opportunities afford when his experience and practice have made the theoretical knowledge of the school the actual individual knowledge of the man. In practical life, the facts of importance in a material way are the ends, not the means. Except as an aid in estimating possible knowledge and ability, the matter of education and experience is of no material importance to the employer. The question is: Can the man properly fill the position for which he applies or for which he is considered? Both education and experience are valueless in practical life unless they can be intelligently applied to useful ends.

There can be no exact measure of the factors that determine individual usefulness in life. Every position has certain definite requirements and these must be fulfilled. For calculations a man must have sufficient mathematical knowledge for his purpose. He who has no such knowledge is useless for such work. If the work requires the exercise of judgment, mathematical knowledge alone is useless; and if fiduciary relations are also involved, character may also become of equal or greater importance. The characteristics discussed in Sec. 9 and their relative percentages of importance, seems to fairly represent a somewhat definite ideal of professional men as to the factors essential to engineering success. The main ends of present day professional education emphasize the last two, although most educators recognize the relative greater importance of the first four which are impressed on the technical student only incidentally if at all with the various subjects taught. To what extent they can and should be impressed on the student is an open question. That these factors must be developed to the extent necessary in every particular case cannot be questioned.

Few technical graduates are of much immediate value either in the office, the factory or the field, and they can make themselves of value only by the acquisition of character, judgment, efficiency, executive ability and the practical ability to apply their technical knowledge to the extent necessary or their individual needs by actual experience in such technical work.

The young graduate is usually incompetent except in minor positions; he commonly overrates his capacity and seldom recognizes his own inexperience and incompetency to fill positions of responsibility and trust. His education gives him the opportunity to secure subordinate employment and to acquire and demonstrate his ability to fill satisfactorily higher positions which may be open to him. Intelligent observation, close application and hard study will fit him for higher positions and better things. He frequently fails to recognize the chances for betterment afforded him by the minor positions which he first secures, and his failure to advance is often largely due to his dissatisfaction in his subordinate position and his personal failure to take advantage of the immediate opportunities offered to acquire practical knowledge and experience and thereby make himself available for advancement.

§ 16. **The Man and the Job.**—To secure the most economical and satisfactory results, both for the job and for the man, it is desir-

able that the man best fitted for each place should secure the position, whatever its importance. This would accomplish the best that the proper exercise of the necessary ability can secure and would permit the development of the individual ability to its maximum.

In practical life such desirable results can only be approximated. Positions and men are often widely separated and consequently the man and the very best position for which he is suited may seldom come in contact. The problem on the one hand is to secure the best available man for a given position, and on the other hand for a man to secure a position in which his services will be satisfactory and which will give him the greatest returns not only in income but in personal satisfaction. As engineering positions are often widely scattered and often far from the centers of technical education, some methods of intercommunication become necessary. A young man through his own connections or acquaintances is frequently in touch with possible openings for technical work. In prosperous years there are so many applications to technical institutions for men to fill subordinate positions that the first position is readily secured, and a letter of recommendation when a vacancy occurs is often all that is necessary. In dull years the difficulty of securing an immediate opportunity for technical work is much greater for then new men are not in great demand. Civil service examinations for national, state and municipal positions are sometimes open to the technical graduate. Letters of inquiry to companies and individuals in charge of engineering work will occasionally lead to opportunities for employment, but as a general rule an employer desires either a personal recommendation from some one with whom he is acquainted either personally or by reputation, or a personal interview with the man who seeks employment.

Letters of application or personal interviews, if apparently promising, should be followed up within a few weeks, otherwise it will usually be assumed that a position has been secured and the application will be ignored.

Letters of recommendation from teachers or former employers will often be of advantage, the former for securing opportunities for minor positions and the latter for more advanced work. Usually only copies of such letters should be sent as in many cases they will not be returned. For higher positions, personal references are often of greater value than letters of recommendation. The letter of recommendation is always favorable or it would not be presented. The letter written direct is likely to give a more correct and complete statement of

the character and ability of the applicant. Where teachers or former employers are to be used as references, where they have not been familiar with the engineer's work for some years, it is desirable to communicate with them, giving a resume of the activities on which the individual has been employed in the intervening time.

A reference to a teacher or employer who has heard nothing of the applicant for five or ten years is not apt to be satisfactory. It is only proper courtesy to secure the personal consent of those to whom it is desired to refer, but if acquaintance warrants reference without such permission, the fact of such reference should be immediately conveyed to the party to whom reference is given.

The various engineering societies make some attempt to bring into communication employees desiring work and employers needing help. This useful function of the technical society should be much further developed.

Advertising for a position may prove of value where a man has acquired considerable special experience or developed in some special line. In such cases an advertisement may attract the attention of those who may be in need of the particular service in question. Employment agencies also offer a means of communication between employees and employers. When these are considered, their standing should be investigated and they should be used with caution.

For higher positions, favorable and wide acquaintance, a clean record and a good personal and professional reputation based on satisfactory service, experience and ability, are the principal factors. These must be acquired by suitable effort and the more widely they become known the better capital they become for the future.

§ 17. Influence.—The value of the influence of family, friends and acquaintances should not be underestimated, but it is equally important that it should not be overrated. Influence frequently brings opportunity, but character, energy and ability are essential to successfully improve the opportunities when offered. The position that is not only acquired by influence but is retained by pull instead of by push is a serious detriment to the individual unfortunate enough to employ such means. The retention of a position by influence dwarfs character, undermines ability, weakens conscience and destroys initiative and personal reputation.

The cultivation of friends and acquaintances, both social and professional, may result in valuable assistance when needed, if the character, ability and experience of the individual warrant its exercise. The

seeking of friends for a purely utilitarian purpose should not be considered, for such aim will surely defeat itself. True friendship must be based on reciprocal esteem, respect and personal regard, founded on both character and ability.

§ 18. **The First Job.**—As a first position an “easy job” is disastrous and leads to habits of indolence and inefficiency. The first work should be hard and exacting so that strenuous effort and concentration may become a habit, for such habits develop men.

A subordinate position with an organization of greater or less magnitude, either in the office, the factory or the field, is the first opportunity for active service that usually comes to the young engineer. Such a position is seldom important in a relative sense but is most important to the individual for it is his first step in practical life, his first chance to “make good”. How will he meet the demands of the situation? His future largely depends on his fitness to fulfill the requirements of the position. If he is interested in his work, is able, accurate, conscientious, dependable and loyal, he has begun the establishment of a reputation which will ultimately lead to success. These qualities will be recognized and his advancement is certain when opportunities occur. Such advancement will follow for it is demanded by the personal interest of the employer, as men with marked characteristics such as described are not to be lost if their services are needed and can be retained on a reasonable basis. If he is interested only in his pay check, if he is careless in his work, heedless of instruction, inaccurate, inattentive, late in arriving and early in leaving his work, these facts will also be noted, his prospects for advancement will be hopeless and he should seek other fields where, if he can eliminate these defects in his character, opportunities for betterment may occur. Many young men fail to appreciate the vital necessity of properly fulfilling subordinate functions or the real importance of such functions.

Each unit is an essential part of the whole. The spire of the cathedral is conspicuous and is seen from afar, but every pile in the foundation is important, and the spire cannot stand without it. So the labor of the artisan, the mechanic and the subordinate is as necessary for the success of the structure as is that of the engineer, the architect or the builder and yet no individual is absolutely essential. If one falls out another will take his place, and the vacancy from the lowest to the highest is soon filled.

Every man should recognize with both pride and humility his own importance and his own insignificance. If he does his duty to his best

ability he is an essential feature in the endeavor of which he is a part. If he fails, he causes only a momentary disturbance, and his disappearance is only of brief interest except to himself and to those who are dependent upon him or especially interested in him.

§ 19. **Improving Opportunities.**—Many young men after securing technical work soon become discontented with their prospects and feel that they have not obtained the position for which their education has fitted them. They fail to make a proper use of their opportunities and soon seek a change in employment with the hope of finding the position for which they are best fitted. They fail to recognize the necessity of so shaping their personal efforts and improving their knowledge and training that their abilities will fit the conditions which opportunities offer. A desire for personal betterment is entirely commendable but it should be exercised so as not to embarrass those who have already given employment. If employment is accepted it entails a conscientious exercise of the ability of the employee, due diligence and loyalty, and a change should be made only when it can be made without undue embarrassment to the organization in which employment has already been secured. In most offices a notice of two weeks or more is given when an employee is to be laid off, unless he is discharged for palpable and reprehensible personal errors of commission or omission. The employee should give no less notice of his intention to leave the place he has accepted.

When a man has accepted a position, it is a duty he owes both to himself and to his employer to do his best to fill the position in the most acceptable manner and to develop all there is in it and in him. Even if the line of service be regarded as temporary and he desires to finally concentrate his efforts in other lines, the self control and self restraint exercised to conquer a difficult or uninteresting subject, the abilities applied and the practical knowledge gained by conscientious study and effort will strengthen his character, increase his ability, enlarge his experience and make him a broader, better and more useful man in whatever field of endeavor he may ultimately be employed.

The man who withholds his best efforts with the hope of expending them ultimately only in the field of his chosen work, so dwarfs himself as to render doubtful any great success in any line. Probably not one-half of the men who graduate from technical courses ultimately enter the exact line of work which they have in mind in their college days. Conscientious and continuous effort in every position position which they may occupy after leaving college will often develop

their capabilities and make apparent their fitness for other lines which in the long run prove more interesting, more remunerative and more satisfactory from every point of view. The satisfactory fulfillment of the first work begins to give the young man a real knowledge of his own needs, his aptitude and defects. His aptitude must be developed, his errors eliminated. The establishment of a reputation for good or for ill is at once begun. Upon the degree of his success and opportunities at hand will depend his advancement. In general, he should retain his position until a promotion is secured or until he has developed himself and this position to their reasonable limits. When there are no opportunities within the organization, he should seek another and better position, leaving his work only after due notice. The young are naturally impatient at delay and expect rapid preferment. They often fail to see the opportunities which are the most obvious and make early changes in employment, to their ultimate disadvantage. A new position should offer some immediate and important advantage or some tangible opportunities, otherwise a change is undesirable, for the organization in which a man has served has the best knowledge and will undoubtedly advance him when the opportunity offers because such advancement is obviously to the logical advantage of all concerned.

§ 20. **Selecting Employment.**—While in many cases opportunities for employment are so limited that little choice is afforded the young engineer in the selection of employment, yet in the long run he may exert considerable control over such selection if he makes careful preparation for his future work. It is evident in most cases that the future rather than the immediate present should be the objective of the young engineer. The line he desires to follow should be based so far as possible on his personal preference and on his personal fitness, aptitudes and abilities. The greatest success will usually come with that line in the pursuit of which he experiences the greatest satisfaction and in which he can exercise to the greatest degree his native abilities and talents and his acquired knowledge and experience. That man is fortunate who finds his professional or business life laid down on the lines he would most gladly follow and who in consequence is most thoroughly interested in the work he is called upon to do. It is evident therefore that immediate salary is of secondary consideration but that employment should be sought in those lines and in those places where both opportunities occur and conditions give promise of ultimate preferment in the lines of the chosen work. Financial embarrassment may occasionally make a different course essential, and in such cases the em-

ployee should endeavor to instill into his work the enthusiasm and interest required for his success. Continuous effort to this end will normally create conditions of satisfaction quite equal to those which would result if he were able to pursue the line to which his early inclinations led.

§ 21. **Salary.**—The amount of salary to be received from a given position is naturally a matter of interest and frequently receives greater consideration than its importance warrants. To the young technical graduate the matters of experience and opportunity are commonly of much greater importance. If a young man is underpaid, he is apt to secure opportunities for a more extended experience than where his compensation is excessive, as for example in the apprentice's position in some of the large manufacturies where opportunities are given to a technical graduate for a broad acquaintance with the machinery designed and constructed through a great variety of work on the testing and erecting floors.

If the salary received is more than should ordinarily be expected in a given position, it commonly means either that the work is temporary or that the man has found a niche into which he fits by unusual aptitude and in which he is likely to remain without the opportunity of acquiring a broader and more extended experience. If the salary is large, the services must be utilized to the greatest advantage in order to make them profitable, which commonly, means that he will be kept on the one particular class of work in which he is especially proficient.

Almost every position affords opportunities for experience and for study. Employment will not be furnished for long unless such employment is profitable to those who furnish it. Advancement will not come until the individual has shown his dependability and his capacity for greater things; and such capacity must be exhibited before and not after the advancement is secured. There are few cases where ability, capacity and dependability are not recognized, and advancement comes when opportunities offer with few exceptions and as a matter of course when these qualities are demonstrated. Few employers will permit employees who have demonstrated their fitness for a position, to leave their service or advance strangers in preference. The employer for his own interests prefers those whose honesty, integrity and ability he knows, and he will seldom look elsewhere to fill an important position unless he is satisfied that such course is necessary in order to secure the desired results.

§ 22. **Change vs. Continuity of Service.**—Formerly it was considered desirable for the young engineer to remain in one position only

long enough to thoroughly familiarize himself with the work, and then to seek other positions where his practical experience might be considerably extended.

At the present time when hundreds of young engineers are graduated from our technical schools each season, it would seem undesirable for any young man to drop a position which gave fair promise of ultimate betterment in order to accumulate a variety of experience which after all may be of little service in his professional career. It would seem by far the better way for the man to thoroughly master every detail of his business and to retain his position if it gives reasonable promise of ultimate betterment rather than to become a wanderer from job to job with each position more difficult to secure as his age increases.

Each man must however be the architect of his own fate. The man who through lack of initiative accepts a permanent subordinate position when he might better himself by a proper change, is perhaps more or less unfortunate; but if he accepts his lot with contentment and is able to satisfy reasonably well his needs and ideals, he must be regarded as reasonably successful; while the ambitious man who frequently changes from place to place in the hopes of ultimately finding the position which best fits his peculiar tastes, aptitudes and personal ambitions, may remain unsatisfied and unsettled through life and in his advanced years be forced into unsatisfactory employment because the position he desires is filled by a younger man. Constant change in position is often evidence of weakness in ability, temperament or character, though it sometimes is the result of lack of opportunity.

During seasons of hard times or panic, when public work has largely ceased and no new investments and establishments are practicable in the railroad and public utilities fields or in the mines and factories, thousands of engineers lose their positions and find nothing in their professional line open for them at any price. They must endeavor to find work in other fields which are perhaps similarly inactive, or await the resumption of business in better times. During such times, the advantage of having secured a position in a permanent organization, and having made the value of the services almost indispensable, is apparent.

§ 23. The Relative Values of Various Classes of Employment. The relative values to the technical man of various classes of professional employment must depend largely on the personal inclination and point of view. Architecture and many special forms of technical work

are definite and after selection require no further comment. The engineering student who has not specialized may perhaps be benefited by a brief discussion of various lines of work in which opportunities for employment may occur.

When the education of the student is general, the opportunities for employment are co-extensive with the whole engineering field. Outside of the field which permits the application of personal aptitude, it makes little difference in what line of employment he begins, as all work furnishes desirable experience. At the end of a series of years he has acquired knowledge and skill in certain definite work, and his chances for the profitable sale of his services are limited to a much narrower field.

Many engineering students have the wrong point of view in regard to the best opportunities for ultimate professional advancement. It has already been noted (see Sec. 12) that the field engineer is the ideal of most engineering students. It is worthy of note that the office almost without exception controls the field and that many men who have had long experience in the field fail of further advancement for the lack of knowledge and experience in office work. Experience in field work usually leads to parallel advancement. The time keeper, the store keeper, and the inspector become the foreman, the superintendent and the resident engineer. Good office work leads to advancement in the office. The able draftsman becomes the designer, the assistant engineer, and with experience, the chief. Surveying and field work in many countries can be done to advantage only at certain periods. Drafting usually offers more steady employment and has the advantage of placing the employee near the responsible head of the organization.

Different classes of employment offer varying advantages. Construction work is often temporary unless with a permanent organization. Unfortunately, many engineering positions have no future. The work is more or less temporary and in dull times and seasons the employment ceases and the employee must look for new fields. In this way he may, and frequently does, pass from one job to another, holding each position until the work is accomplished, and never becoming settled or a permanent part of any engineering organization.

Engineering employment may often lead to business opportunities. The young man with capacity who, after he has acquired the experience which can be obtained in engineering positions connected with great industries, has the foresight and the energy to drop out of line of promotion which may be of only limited opportunities, and to take a

position through which he will acquire a knowledge of operation, maintenance and general business management, will frequently be rewarded by placing himself in line for greater business opportunities than are possible if he confines his efforts to the purely engineering phases of the work. Public service corporations offer many opportunities for ultimate advancement. Employment with such corporations may frequently result in permanent positions, and a qualified man will advance slowly but surely and may ultimately reach the highest position which such corporations have to offer.

It is exceedingly desirable for the engineer to become at an early date a part of a permanent organization in a line which he will be content to follow as a permanent life work. If a change into another line is desirable, it should be made at an early date; delay greatly complicates the situation. If he withdraws from one line of work and enters another after considerable advancement has been attained, it must usually be at the expense of salary, for he will not have the value in any other line without acquired experience.

Foreign service is subject to the same disadvantage and should be regarded as a permanent life work, or abandoned early for work at home. Work in a foreign country involves a loss of touch with home conditions and professional acquaintance, and a change after some years abroad often results in the necessity of accepting a subordinate position at a greatly reduced salary.

Employment in the government service has certain advantages and certain disadvantages. Compensation in the minor positions is usually equal or greater than that which can be secured in private work, but the higher positions are not so well paid. On the other hand, those who reach advanced positions and display reasonable ability are assured of permanent positions. Instructional work in technical institutions is subject to the same comments. Such positions offer many opportunities for development but they do not demand the constant exercise of energy and the continuous effort which are common to commercial work. If the individual lacks initiative and force, the opportunities for retaining the positions with a minimum of effort are conspicuous, and inclination in that direction will soon unfit the individual for any important positions in commercial work. Whatever the work of the engineer may be his aim should be to properly do the work at hand, to study and to improve. Advancement, where opportunities offer, will take care of itself if the young engineer by his acquisition of knowledge and skill is ready for promotion.

§ 24. **Private Practice.**—The great majority of engineering positions are salaried positions. Probably less than ten per cent. of the engineering profession is engaged in what is termed "private practice." In such work the compensation is generally based on either a per diem basis or on a percentage of the cost of the work which is undertaken. In such practice the engineer usually furnishes all the assistants necessary for the making of the original surveys, the designs and plans, and for supervising the construction, and occasionally some of the larger organizations of this kind undertake the actual construction of the work as well.

For success in private practice, at least on the larger and more important works, extended experience on a great variety of work is required, for in general the work of a private office cannot be devoted to a single specialty, although it is usually confined to certain definite related lines.

Occasionally a young man just out of college with only a few years of practice behind him attempts to enter private practice. If such work is confined to simple service such as drafting, surveying, etc., in which reasonable experience and adaptness have been attained, such a venture is justifiable. When however the young engineer offers to the public inadequate experience, unsound judgment and insufficient skill for the proper performance of the work he desires to undertake, his attempt is unjustifiable and immoral. The sale of skill and knowledge which are not possessed is fraud, and although such a business may be conducted in such a manner as to escape the legal liabilities involved by misrepresentation, the moral sense is sacrificed with resulting permanent injury to the professional success of him who pursues such a course. Most attempts of this kind result in the failures which are rightly their due. If sufficient work is secured to pay expenses, it must usually be secured at a price too low for the class of services which should be rendered. Without broad experience proper services cannot be rendered, and on account of the low price received for his work, he is often unable to furnish even the best services of which he is capable. The results are unfortunate. He leaves behind him a record of work inadequately conceived and improperly done. He has mortgaged his future for an opportunity for an early professional preferment for which he was unprepared and he can never become more than of minor grade in his professional work.

§ 25. **Duties to Subordinates.**—While much has been said of the duties of the employee in the performance of his work, such duties

are by no means reduced when he reaches a position where others are subject to his direction and supervision. As previously stated (Sec. 3), with professional advancement higher obligations are assumed and such obligations should be exercised not only toward the client or superior, but toward the subordinate as well. The engineer should advise and assist his subordinates and give them every reasonable encouragement and incentive to excel in their work. Criticism and reproof where necessary should be administered kindly and with the idea of improvement, and praise and commendation should be offered for initiative, skill and accuracy. Jealousy of subordinates and the consequent failure to advise and assist them or to give them suitable credit for valuable ideas or suggestions is the sign of limited ability or an ungenerous disposition. The promotion of subordinates should be made on the basis of actual merit and not on the basis of capricious preference. If the superior is employing his subordinates for others, he is especially bound to consider intrinsic worth instead of personal preferment.

In dealing with artisans and workmen a similar course of action is desirable. Nothing is gained and much is lost by harshness, conceit, and overbearing conduct. A feeling of injustice and resentment is seriously detrimental to the esprit de corps of any engineering force in the office or the field, and every force is bound to exhibit to a considerable degree the spirit displayed by those in authority.

§ 26. **Duties to Clients.**—The relations of the engineer to his clients are fiduciary in nature and therefore involve, both legally and morally, obligations which must be exercised even at the sacrifice of personal interests. The client must place his trust in the personal honesty, business integrity and professional ability of his engineer. Frequently this trust involves not only large construction cost but the successful outcome of an endeavor of great importance. The client is frequently entirely ignorant of the technical features of the work and is only interested in it as a business venture. He may know nothing of the hazards or contingencies involved, and cannot judge of the relative values and costs of different methods of development, different materials and machines or the effects of the same on the ultimate aims to be attained. The engineer must stand between his client and all adverse interests. The desire of the contractor to cheapen the work of construction, the desire of the manufacturer to secure the sale of more or less suitable machinery, the desire of the promoter to finance more or less questionable ventures, and many other interests must be carefully scrutinized, fairly considered, and properly adjusted.

To be a suitable adviser for such responsible positions, the engineer's loyalty must be beyond question; his only interest must be that of his client in every right and proper way. "No man can serve two masters for either he will hate the one and love the other, or else he will hold to the one and despise the other." (Matt. 6:24). This principle has been recognized as essential by the best men of every age and nation and in every business and profession. If the engineer has adverse interests of any kind, no matter how innocent they may appear, they will bias his judgment and he will do less than his duty. It is the insidious interest which has no apparent relation to the immediate work of engineering rather than the action that is rankly dishonest that is to be feared, for through such interests the first serious misstep may be taken.

It is not believed to be essential to discuss here the necessity of absolute honesty in such work, personal interests with contractors, profits from the sale of materials, commissions from manufacturers, collusion with promoters, are not only obviously dishonorable and dishonest, but so unquestionably immoral and against public policy that they render the individual amenable to the law. No one who respects his profession or who hopes for professional preferment could possibly yield to such gross temptation.

§ 27. **Consultation.**—Commonly the man who is called upon to take charge of an important endeavor is one who has developed more or less special knowledge and ability in the principal field which with other phases constitutes the project. When a young engineer has been advanced to a position of responsibility and authority on a project of this nature he often feels that the importance of his position demands an exhibition of learning and ability that is often entirely beyond his capacity. Nevertheless he is frequently impelled to attempt professional ventures quite beyond his experience rather than to acknowledge that even his abilities have their natural limitation. In this manner young men of undoubted ability frequently attempt professional work of a special nature for which they are in no way qualified, and risk the success of their employer's interests in a manner that is unjust and unwarranted. While such attempts are usually attended with more or less success, they usually fail to accomplish the results that might be attained by such expert service and wrongly deprive the client of the very best results. No man can be uniformly expert on all branches covered by many projects, and it is the sign of a narrow mind and limited ability for a man not to recognize his own limitations or to

fail to call in expert aid when such aid can be used to advantage in his client's service.

§ 28. **Duties to the Profession.**—Every professional man is greatly indebted to his profession. His knowledge and usefulness have been greatly augmented by the labor and investigation, the successes and the failures of those who have gone before. The proceedings of technical societies, the articles in the technical press, the treatises on technical subjects and the opportunities of technical schools all afford the engineer occasion to enlarge his knowledge, expand his experience, increase his usefulness and make himself of greater value to himself and to the public. The high ideals and the distinguished ability that have been exercised by the men to the profession in the past bring to the professional man a consideration and standing which he could not otherwise enjoy. It is self-evident therefore that he who enjoys the manifold benefits to be derived from the lives and labors of those who are his associates or have preceded him in his profession, is morally bound to maintain such ideals and conserve such respect by the exercise of his best judgment and best ability and by a high conception of personal responsibility and of personal honor, and by a corresponding exercise of such ideals in his professional work.

§ 29. **The Engineer in Business.**—Engineering training affords a suitable foundation not only for professional work but also for various other occupations and vocations. It is a satisfactory training for the subordinate position of foremen, superintendents, salesmen and preliminary to entering the field of contracting for the construction of engineering work, for the manufacture of machinery, engineering materials and supplies, and other occupations which have to do with or are intimately related to engineering work. Almost all that has been said of other activities applies to these and to any other lines of work in which the engineer may engage, whether directly or indirectly connected with technical affairs or in fields quite foreign to such matters. Honorable and conscientious service, intelligent application, considerate action and high ideals are the passports to high standing, public confidence and business preferment.

§ 30. **The Engineer as a Citizen.**—The failure of engineers as a class to take part in social and political activities is largely responsible for the lack of appreciation of the public at large for the engineering profession. The work of the engineer is often far from the public eye, in the office and in the field. He is often away from home and his mind is so concentrated on his work and on his duties that he is apt to

avoid the public and is often almost a stranger in his own town except among his personal friends. No man should become so engrossed in his business or profession that he forgets or neglects his duties as a citizen. The engineer should lend his aid and support to every beneficial public movement and should be especially active in shaping public opinion and securing proper legislative action along those lines on which he is especially informed through his professional training and activities. In many matters in which the engineer is best informed the public needs advice and assistance. Agitators and politicians frequently encourage for their own ends popular prejudice for or against government action along lines with which the engineer is familiar or of which, through his training in the analysis of conditions and the determination of facts, he is best fitted to judge. The public is largely ignorant of the true principles underlying conservation, inland waterways, preparedness, public improvements, sanitation, municipal ownership, and many other questions with which the engineer is or may easily become familiar. With many of these subjects, unless there is an enlightened public opinion, the public through its legislators or members of congress, is liable to deal unwisely and unjustly. It is a duty of the engineer as a citizen to give the public the benefit of his training and practical experience in these various matters on which he is particularly able to render valuable service.

Efficient and effective service in such matters will not only be of benefit to the public but will be of great value to the individual and enhance the reputation of the profession in the minds of the people.

§ 31. **Conduct of Professional Practice.**—The conduct of the engineer or architect in the practice of his profession should be governed by a strict regard for the rights of others and an appreciation of the duties he, as a professional man, owes to all with whom he has business relations. The American Institute of Architects offers certain advice relative to the principles of professional practice, which it recommends to its members.¹ In most respects this advice is directly applicable to engineering practice as well. While these principles may not seem directly applicable to the conduct of the young engineer in minor professional positions, they contain the basic principles on which all such conduct should rest, and if read in connection with the codes of ethics which follow, will furnish the necessary information for the proper course of individual action in most cases.

¹ Reprinted from the "Quarterly Bulletin" of the American Institute of Architects. Adopted by the Institute at the Washington convention, Dec. 14-16, 1909.

The American Institute of Architects, seeking to maintain a high standard of practice and conduct on the part of its members as a safeguard of the important financial, technical and esthetic interests entrusted to them, offers the following advice relative to professional practice:

The profession of architecture calls for men of the highest integrity, business capacity and artistic ability. The architect is entrusted with financial undertakings in which his honesty of purpose must be above suspicion; he acts as professional adviser to his client and his advice must be absolutely disinterested; he is charged with the exercise of judicial functions as between client and contractors and must act with entire impartiality; he has moral responsibilities to his professional associates and subordinates; finally, he is engaged in a profession which carries with it grave responsibility to the public. These duties and responsibilities cannot be properly discharged unless his motives, conduct and ability are such as to command respect and confidence.

No set of rules can be framed which will particularize all the duties of the architect in his various relations to his clients, to contractors, to his professional brethren, and to the public. The following principles should, however, govern the conduct of members of the profession and should serve as a guide in circumstances other than those enumerated:

1. *Architect's Status*.—The architect's relation to his client is primarily that of professional adviser; this relation continues throughout the entire course of his service. When, however, a contract has been executed between his client and a contractor by the terms of which the architect becomes the official interpreter of its conditions and the judge of its performance, an additional relation is created under which it is incumbent upon the architect to side neither with client nor contractor, but to use his powers under the contract to enforce its faithful performance by both parties. The fact that the architect's payment comes from the client does not invalidate his obligation to act with impartiality to both parties.

2. *Preliminary Drawings and Estimates*.—The architect at the outset should impress upon the client the importance of sufficient time for the preparation of drawings and specifications. It is the duty of the architect to make or secure preliminary estimates when requested, but he should acquaint the client with their conditional character and inform him that complete and final figures can be had only from complete and final drawings and specifications. If an unconditional limit of cost be imposed before such drawings are made and estimated, the architect must be free to make such adjustments as seem to him necessary. Since the architect should assume no responsibility that may prevent him from giving his client disinterested advice, he should not, by bond or otherwise, guarantee any estimate or contract.

3. *Superintendence and Expert Services*.—On all work except the simplest, it is to the interest of the owner to employ a superintendent or clerk-of-the-works. In many engineering problems and in certain specialized

esthetic problems, it is to his interest to have the services of special experts and the architect should so inform him. The experience and special knowledge of the architect make it to the advantage of the owner that these persons, although paid by the owner, should be selected by the architect under whose direction they are to work.

4. *The Architect's Charges.*—The Schedule of Charges of the American Institute of Architects is recognized as a proper minimum of payment. The locality or the nature of the work, the quality of services to be rendered, the skill of the practitioner or other circumstances frequently justify a higher charge than that indicated by the schedule.

5. *Payment for Expert Service.*—The architect when retained as an expert, whether in connection with competitions or otherwise, should receive a compensation proportionate to the responsibility and difficulty of the service. No duty of the architect is more exacting than such service, and the honor of the profession is involved in it. Under no circumstances should experts knowingly name prices in competition with each other.

6. *Selection of Bidders or Contractors.*—The architect should advise the client in the selection of bidders and in the award of the contract. In advising that none but trustworthy bidders be invited and that the award be made only to contractors who are reliable and competent, the architect protects the interests of his client.

7. *Duties of the Contractor.*—As the architect decides whether or not the intent of his plans and specifications is properly carried out, he should take special care to see that these drawings and specifications are complete and accurate, and he should never call upon the contractor to make good oversights or errors in them nor attempt to shirk responsibility by indefinite clauses in the contract or specifications.

8. *Engaging in the Building Trades.*—The architect should not directly or indirectly engage in any of the building trades. If he has any financial interest in any building material or device, he should not specify or use it without the knowledge and approval of his client.

9. *Accepting Commissions or Favors.*—The architect should not receive any commission or any substantial service from a contractor or from any interested person other than his client.

10. *Encouraging Good Workmanship.*—The large powers with which the architect is invested should be used with judgment. While he must condemn bad work, he should commend good work. Intelligent initiative on the part of craftsmen and workmen should be recognized and encouraged and the architect should make evident his appreciation of the dignity of the artisan's function.

11. *Offering Services Gratuitously.*—The seeking out of a possible client and the offering to him of professional service on approval and without compensation, unless warranted by personal or previous business relations, tends to lower the dignity and standing of the profession and is to be condemned.

12. *Advertising.*—Advertising tends to lower the dignity of the profession and is therefore condemned.

13. *Signing Buildings and Use of Titles.*—The display of the architect's name upon a building under construction is condemned, but the unobtrusive signature of buildings after completion has the approval of the Institute. The use of initials designating membership in the institute is proper in connection with any professional service and is to be encouraged as helping to make known the nature of the honor they imply.

14. *Competitions.*—An architect should not take part in a competition as competitor or professional adviser or juror unless the competition is to be conducted according to the best practice and usage, of the profession as formulated by the institute. Except as an authorized competitor, he may not attempt to secure work for which a competition has been instituted. He may not attempt to influence the award in a competition in which he has submitted drawings. He may not accept the commission to do the work for which a competition has been instituted if he has acted in an advisory capacity either in drawing the program or in making the award.

15. *Injuring Others.*—An architect should not falsely or maliciously injure directly or indirectly, the professional reputation, prospects or business of a fellow architect.

16. *Undertaking the Work of Others.*—An architect should not undertake a commission while the claim for compensation or damages, or both, of an architect previously employed and whose employment has been terminated remains unsatisfied, unless such claim has been referred to arbitration or issue has been joined at law; or unless the architect previously employed neglects to press his claim legally; nor should he attempt to supplant a fellow architect after definite steps have been taken toward his employment.

17. *Duties to Students and Draftsmen.*—The architect should advise and assist those who intend making architecture their career. If the beginner must get his training solely in the office of an architect, the latter should assist him to the best of his ability by instruction and advice. An architect should urge his draftsmen to avail themselves of educational opportunities. He should, as far as practicable, give encouragement to all worthy agencies and institutions for architectural education. While a thorough technical preparation is essential for the practice of architecture, architects cannot possibly insist too strongly that it should rest upon a broad foundation of general culture.

18. *Duties to the Public and to Building Authorities.*—An architect should be mindful of the public welfare and should participate in those movements for public betterment in which his special training and experience qualify him to act. He should not, even under his client's instructions, engage in or encourage any practices contrary to law or hostile to the public interest; for as he is not obliged to accept a given piece of work, he cannot, by urging that he has but followed his client's instructions, escape the condemnation attaching to his acts. An architect should support all public officials who have charge of building in the rightful performance of their legal duties. He should carefully comply with all building laws and regulations,

and if any such appear to him unwise or unfair, he should endeavor to have them altered.

19. *Professional Qualifications*.—The public has the right to expect that he who bears the title of architect has the knowledge and ability needed for the proper invention, illustration and supervision of all building operations which he may undertake. Such qualifications alone justify the assumption of the title of architect.

LITERATURE

Industrial Leadership, by H. L. Gault. Yale University Press, New Haven.

Trade Morals, by E. D. Page. Yale University Press, New Haven.

Morals in Modern Business. Yale University Press, New Haven.

Everyday Ethics. Yale University Press, New Haven.

Ethics in Service, by W. H. Taft. Yale University Press, New Haven.

Analyzing Character, by Blackford and Newcomb. Review of Reviews Co., New York.

The Job, the Man, the Boss, by Blackford and Newcomb. Review of Reviews Co., New York.

The Engineer and the Social Problems. Discussion of the duty of the engineer to society. Presidential address to American Society of Civil Engineers, June, 1913, by George F. Swain. *Can. Eng. Vol. 24*, p. 918 and *Vol. 25*, p. 119.

Present Day Tendencies and Problems and the Relation of the Engineer to them. Abstract of address by George F. Swain. *Eng. Rec. Vol. 67*, p. 722. See also *Eng. News, Vol. 69*, p. 1346.

The Engineer in Public Service. Abstract of Address to Class of Case School by F. H. Newell. *Eng. News, Vol. 68*, p. 153.

The Relation of the Engineer to Life. Address to Western Society of Engineers, Jan. 11, 1911 by John W. Alvord.

The Relation of Engineering to Economics. Discussion of the effects engineering had had upon the economic conditions by William Kent. *Eng. News, Vol. 34*, p. 156.

Deficiency in Personality Responsible for Engineers Failure to Receive Recognition. Address by Prof. G. F. Swain before American Institute of Electrical Engineers. Compares qualities for leadership of engineers and lawyers. *Eng. Rec. Vol. 71*, p. 261.

Relations between Customer, Consulting Engineer and Electrical Manufacturer. Abstract of paper before New York Electrical Society. Discusses duty and usefulness of Engineer. S. Dana Greene. *Eng. News, Vol. 39*, p. 45.

Relation of the Consulting Engineer to the Operating Engineer. Discusses desirability of harmony between them. F. W. Rose. *Eng. Rec. Vol. 67*, p. 497.

The Consulting Engineer and the Municipal Engineer. Qualifications necessary for good engineer and duties of each class. H. C. H. Shenton. *Con. Eng. Vol. 25*, p. 249.

Some Public Relations of the Engineer. Opportunities for the engineer in social service. M. N. Baker. *Eng. News, Vol. 65*, p. 346.

The Commercial side of Engineering. Discusses development of efficient methods. W. M. McFarland. Cassiers Mag. Jan. 1904.

The Commercial Aspect of Engineering. Discussion of business side of engineering, salesmanship, etc. Chas. A. S. Howlett. Jour. W. S. E. Feb. 1905.

The Engineer in Civic Affairs. Editorial. Elect. Rev. & West. Elect. Vol. 61, p. 195.

The Relations of Engineers and Contractors. Discussion of some conditions which produce hardships. Address before First American Road Congress. By Capt. D. L. Hough. Eng. Rec. Vol. 64, p. 644.

The Engineer in Business. Desirability of honesty and economy in the engineering work. Editorial. Eng. Rec. Vol. 54, p. 536.

The Engineer as a Citizen. Discussion of engineering education and the duties of the engineer as a citizen. Address by President Alex. C. Humphreys at the University of Pennsylvania. Eng. Rec. Vol. 54, p. 465.

Ethical Relation between the Draftsman and the Mechanical Engineer. Discusses some questions of ethics to be observed in subordinate position. F. R. Hutton. Eng. News, Vol. 69, p. 71.

CHAPTER IV

PERSONAL AND ETHICAL RELATIONS

§ 32. **Limitations of Positive Law.**—The necessity of a guide to human conduct has been recognized in every age and by every people. With primitive people, might made right, and force was the basis of the settlement of disputes until this became recognized as an unsatisfactory and a needlessly expensive method for the adjustment of social relations. Even today in international relations, the law of might is frequently exercised and such exercise is a sad commentary on our present so-called civilization. The necessity for satisfactory, established social and business relations resulted in the establishment of positive law which, while it has grown, developed and improved, still leaves much to be desired.

While positive law fixes certain social and business obligations between individuals, and provides a method by which further obligations can be established by agreement, yet even where an attempt is made in a contract to specify in the greatest detail the limitations of such obligations, there are many points of contact in both social and business intercourse over which no successful legal control can be established.

Positive law is an attempt to crystalize the ideas and convictions of the citizens of a country as to those obligations and that conduct which, established by custom, usage and experience, seem to afford the greatest degree of justice and equity under average conditions in the relationship of man to man. Such laws fall so far short of accomplishing their object that courts of equity have been established to mitigate and supplement the law in cases where strict legal relief is impracticable.

Laws were originally enacted with the object of protecting particularly the established rights of the ruling class, and were modified to benefit the more unfortunate only as revolution or change in the moral and ethical view of the people required. Even today undue weight is frequently given to vested and property right, to the detriment of the unfortunate. While the observance of legal rights is highly important, still a society in which none but legal rights are recognized would constitute a most unhappy community.

§ 33. **Ethics.**—While the law defines the privileges of the individual in the larger matters of life, it does not always assure equity and justice even in those matters, and is a guide to a limited extent only in the every day relations of man to man. The individual conduct in those manifold intimate relations which are not governed by legal enactments has more to do with character and success than the observation of mere legal requirements. It is not sufficient that the law be observed, for a man may live strictly within the law and be most undesirable as a citizen, friend or neighbor.

To the honorable business or professional man, the question of a legal right in regard to a course of conduct is of secondary importance to the ethical right, and he will not exercise legal rights which are not also morally sound. As has already been pointed out, the law only approximates justice and equity, and frequently in its application falls far short of the object. Then again, the exercise of a legal right sometimes involves legal action, which in turn requires an expenditure of time and money often unwarranted by the results which may be attained; so the legal right, while equitable, may not be enforced on account of the trouble involved. Unfortunately there are men who are willing to take advantage of all laws favorable to themselves even though entirely unjust, and to take advantage of the unwillingness of others to sustain their rights in court and to trespass on those legal rights so far as can safely be done.

Moral and ethical principles undoubtedly began to develop prior to the establishment of even the most primitive forms of positive law and have grown and developed concomitant with the development of the law. Mankind has long recognized the imperfections in positive law and has attempted to control through religion and moral associations and societies and through established public opinion, those human actions which need control for the general and individual good but which positive law has failed to effect. In general every country has a certain moral or ethical standard which may be regarded as established by custom and common approval. Such standards are more or less imperfect. True ethical principles are not a matter of custom but are well understood and have been recognized by the best men in all ages and in all walks of life. The ethical code established by custom changes with the development of society and can reach perfection only when society develops morally far beyond its present condition.

The net practical results of the ethical development of any nation must be adjudged by the existing conditions. Social conditions which

will permit of so much crime and poverty as now exist in every country, are not ideal and these conditions which now obtain are undoubtedly largely due to the unethical legal and social organization of society and to ignorance of how best to accomplish the desired results, and unwillingness to waive personal advantage in favor of moral obligations. In every society there are individuals who fail to recognize, or at least to exercise, even those ethical and moral obligations which are regarded as well founded by the society in which they live, and who undoubtedly accomplish certain desired results and derive certain profits and apparent advantages by such disregard. Humanity is weak, and few individuals have lived active lives in constant contact with their fellow men, who have always observed those ethical obligations which they in their conscience recognize as morally just and equitable.

§ 34. **Formation of Individual Principles.**—It is essential that every individual who is to take part in business or professional life should adopt or form individual principles of action for guidance in his relations to others with whom he must necessarily come in contact, for without such principles he will not be able to act promptly and he will be uncertain in his relation to men, and often be led into embarrassing positions with possible loss of his self-respect and reputation. The principles to be adopted should be sound and, at least until substantiated by personal experience, should be based on the consensus of opinion of those men to whom the individual looks up with confidence and respect. Without such principles mistakes are certain and the individual may be led into a course of action which will seriously affect his future.

The first step in unethical conduct is often inadvertent and is made through ignorance. Conditions often render further departure apparently expedient or necessary. The moral ideals become blunted, and ethical principles are ignored because of the unethical attitude of associates and competitors, and are ignored with the thought or expression that "If we go to Rome we must do as the Romans," or "If we do not do this some one else will." On such false ideas the downward path begins; and ends where?

There can be no question that as a basis of a successful life, and entirely apart from moral and religious ideals, "Honesty is the best policy." Even those who have occasion to use the services of a dishonest person cast him aside when his immediate use is over, well knowing that he who will sell himself once may do so a second time, and to the detriment of his first employer. The material profit which may tem-

porarily accrue from unethical conduct so dwarfs the intellects of those who yield to its temptation that it is bound to lead to moral and professional ruin.

It is therefore essential in business and in professional life that the individual be honest, preferably from an ethical and moral standpoint, but if not from this point of view, then certainly from the standpoint of policy.

At the best, life is brief, and true usefulness and happiness should be its aim, and while the engineer or other professional or business man may acquire comparatively little wealth, he can and should own himself, and his dearest possession should be a spotless reputation. Honesty and integrity lead to dependability. No amount of knowledge or work can take the place of these attributes. The man who can be depended upon is ever in demand, and if he has also acquired a high degree of knowledge and experience and an appetite for hard work, his true success, barring accidents, is assured.

§ 35. Specifications for a Man.*—

"To respect my country, my profession, and myself. To be honest and fair with my fellow men as I expect them to be with me. To be a loyal citizen of the United States. To speak of it with praise and act always as a trustworthy custodian of its good name. To be a man whose name carries prestige with it wherever it goes.

"To base my expectations of a reward on a solid foundation of service rendered. To be willing to pay the price of success in honest effort. To look upon my work as an opportunity to be seized with joy and to be made the most of, not as a painful drudgery to be reluctantly endured.

"To remember that success lies within my own self and in my own brain, my own ambition and my own courage and determination. To expect difficulties and force my way through them. To turn hard experience into capital for future struggles.

"To believe in my profession heart and soul. To carry an air of optimism in the presence of those I meet. To dispel all temper with cheerfulness, kill doubts with strong conviction, and reduce action with an agreeable personality.

"To make a study of my business. To know my profession in every detail. To mix brains with effort and system in my work. To find time to do every needful thing by not letting time find me doing nothing. To hoard days as a miser does dollars. To make every hour bring me dividends in increased knowledge and healthful recreation. To keep my future unencumbered with debts. To save as well as to earn.

*Found among the papers of Thomas J. Van Alostyn, a graduate of the Electrical Engineering department of Cornell University after his death which occurred on the job.—*Cornell Civil Engineer*, Vol. 23, p. 154.

"To cut out expensive amusements until I can afford them. To steer clear of dissipation and guard my health of body and peace of mind as a most precious stock in trade.

"Finally to take a good grip on the joys of life. To play the game like a man. To fight against nothing as hard as my own weakness and endeavor to give it strength. To be a gentleman and a Christian so I may be courteous to man, faithful to friends, and true to God."

§ 36. **Code of Ethics.**—Within the last ten years (1916) the discussions of professional ethics have crystalized into the various codes of ethics which have been adopted by many technical societies. These codes do not presume to define all of the duties and obligations of the individual toward life, but express as far and as clearly as practicable the principles which should govern the professional relations of the engineer or architect to his client or employer, to other professional men, and to the public. While in general these codes are intended to apply to the conduct of the professional man in independent practice, they also afford valuable suggestions to the young engineer or architect as to his personal course of conduct.

They are an expression of ideas which every man should thoughtfully consider.

These codes are however, rules which cover only a few features of professional conduct and entirely ignore the more important and more personal relations. They do not cover the field of ethics and a professional man who follows them implicitly may depart in many ways from a proper ethical standard in his personal life.

The man of experience and of high ideals who desires to live a life of usefulness and honor needs no formal code of ethics to guide his personal or professional conduct.

§ 37. **The Canons of Ethics of the American Institute of Architects.**—The following canons are adopted by the American Institute of Architects as a general guide, yet the enumeration of particular duties should not be construed as a denial of the existence of others equally important although not specifically mentioned. It should also be noted that the several sections indicate offenses of greatly varying degrees of gravity.

It is unprofessional for an architect—

1. To engage directly or indirectly in any of the building trades.
2. To guarantee an estimate or contract by bond or otherwise.
3. To accept any commission or substantial service from a contractor or from any interested party other than the owner.
4. To advertise.

5. To take part in any competition the terms of which are not in harmony with the principles approved by the Institute.

6. To attempt in any way, except as a duly authorized competitor, to secure work for which a competition is in progress.

7. To attempt to influence, either directly or indirectly, the award of a competition in which he is a competitor.

8. To accept the commission to do the work for which a competition has been instituted if he has acted in an advisory capacity, either in drawing the program or in making the award.

9. To injure falsely or maliciously, directly or indirectly, the professional reputation, prospects or business of a fellow architect.

10. To undertake a commission while the claim for compensation or damages, or both, of an architect previously employed and whose employment has been terminated remains unsatisfied, until such claim has been referred to arbitration or issue has been joined at law, or unless the architect previously employed neglects to press his claim legally.

11. To attempt to supplant a fellow architect after definite steps have been taken toward his employment.

12. To compete knowingly with a fellow architect for employment on the basis of professional charges.

§ 38. Code of Professional Ethics of The American Institute of Consulting Engineers.²—It shall be considered unprofessional and inconsistent with honorable and dignified bearing for any member of The American Institute of Consulting Engineers:

1. To act for his clients in professional matters otherwise than in a strictly fiduciary manner or to accept any other remuneration than his direct charges for services rendered his clients, except as provided in Clause 4.

2. To accept any trade commissions, discounts, allowances, or any indirect profit or consideration in connection with any work which he is engaged to design or to superintend, or in connection with any professional business which may be entrusted to him.

3. To neglect informing his clients of any business connections, interests or circumstances which may be deemed as influencing his judgment or the quality of his services to his clients.

4. To receive, directly, or indirectly, any royalty, gratuity, or commission on any patented or protected article or process used in work upon which he is retained by his clients, unless and until receipt of such royalty, gratuity or commission has been authorized in writing by his clients.

5. To offer commissions or otherwise improperly solicit professional work either directly or by an agent.

6. To attempt to injure falsely or maliciously, directly or indirectly, the professional reputation, prospects or business of a fellow engineer.

7. To accept employment by a client while the claim for compensation or damages, or both, of a fellow engineer previously employed by the same client and whose employment has been terminated, remains unsatisfied or

² Authorized by the council, June 23, 1911.

until such claim has been referred to arbitration or issue has been joined at law or unless the engineer previously employed has neglected to press his claim legally.

8. To attempt to supplant a fellow engineer after definite steps have been taken toward his employment.

9. To compete with a fellow engineer for employment on the basis of professional charges by reducing his usual charges and attempting to underbid after being informed of the charges named by his competitor.

10. To accept any engagement to review the work of a fellow engineer for the same client, except with the knowledge or consent of such engineer or unless the connection of such engineer with the work has been terminated.

§ 39. **Code of Principles of Professional Conduct of The American Institute of Electrical Engineers.**³—While the following principles express, generally the engineer's relations to client, employer, the public, and the engineering fraternity, it is not presumed that they define all of the engineer's duties and obligations.

(A) GENERAL PRINCIPLES.

1. In all of his relations the engineer should be guided by the highest principles of honor.

2. It is the duty of the engineer to satisfy himself to the best of his ability that the enterprises with which he becomes identified are of legitimate character. If after becoming associated with an enterprise he finds it to be of questionable character, he should sever his connection with it as soon as practicable.

(B) THE ENGINEER'S RELATIONS TO CLIENT OR EMPLOYER.

3. The engineer should consider the protection of a client's or employer's interests his first professional obligation, and, therefore, should avoid every act contrary to this duty. If any other considerations, such as professional obligations or restrictions, interfere with his meeting the legitimate expectation of a client or employer, the engineer should inform him of the situation.

4. An engineer cannot honorably accept compensation, financial or otherwise, from more than one interested party, without the consent of all parties. The engineer, whether consulting, designing, installing or operating, must not accept commissions, directly or indirectly, from parties dealing with his client or employer.

5. An engineer called upon to decide the use of inventions, apparatus, or anything in which he has a financial interest, should make his status in the matter clearly understood before engagement.

6. An engineer in independent practice may be employed by more than one party, when the interests of the several parties do not conflict; and it should be understood that he is not expected to devote his entire time to the work of one, but is free to carry out other engagements. A consulting engi-

³ Adopted by the board of directors, March 8, 1912.

neer permanently retained by a party, should notify others of the affiliation before entering into relations with them, if, in his opinion, the interests might conflict.

7. An engineer should consider it his duty to make every effort to remedy dangerous defects in apparatus or structures or dangerous conditions of operation, and should bring these to the attention of his client or employer.

(C) OWNERSHIP OF ENGINEERING RECORDS AND DATA.

8. It is desirable that an engineer undertaking for others work in connection with which he may make improvements, inventions, plans, designs, or other records, should enter into an agreement regarding their ownership.

9. If an engineer uses information which is not common knowledge or public property, but which he obtains from a client or employer, the results in the forms of plans, designs or other records, should not be regarded as his property, but the property of his client or employer.

10. If an engineer uses only his own knowledge, or information, which by prior publication, or otherwise, is public property and obtains no engineering data from a client or employer, except performance specifications or routine information, then in the absence of an agreement to the contrary the results in the form of inventions, plans, designs, or other records, should be regarded as the property of the engineer, and the client or employer should be entitled to their use only in the case for which the engineer was retained.

11. All work and results accomplished by the engineer in the form of inventions, plans, designs, or other records, that are outside of the field of engineering for which a client or employer has retained him, should be regarded as the engineer's property unless there is an agreement to the contrary.

12. When an engineer or manufacturer builds apparatus from designs supplied to him by a customer, the designs remain the property of the customer and should not be duplicated by the engineer or manufacturer for others without express permission. When the engineer or manufacturer and a customer jointly work out designs and plans or develop inventions a clear understanding should be reached before the beginning of the work regarding the respective rights of ownership in any inventions, designs, or matters of similar character, that may result.

13. Any engineering data or information which an engineer obtains from his client or employer, or which he creates as a result of such information, must be considered confidential by the engineer; and while he is justified in using such data or information in his own practice as forming part of his professional experience, its publication without express permission is improper.

14. Designs, data, records and notes made by an employee and referring exclusively to his employer's work, should be regarded as his employer's property.

15. A customer, in buying apparatus, does not acquire any right in its design but only the use of the apparatus purchased. A client does not acquire any right to the plans made by a consulting engineer except for the specific case for which they were made.

(D) THE ENGINEER'S RELATIONS TO THE PUBLIC.

16. The engineer should endeavor to assist the public to a fair and correct general understanding of engineering matters, to extend the general knowledge of engineering, and to discourage the appearance of untrue, unfair or exaggerated statements on engineering subjects in the press or elsewhere, especially if those statements may lead to, or are made for the purpose of, inducing the public to participate in unworthy enterprises.

17. Technical discussions and criticisms of engineering subjects should not be conducted in the public press, but before engineering societies, or in the technical press.

18. It is desirable that the first publication concerning inventions or other engineering advances should not be made through the public press, but before engineering societies or through technical publications.

19. It is unprofessional to give an opinion on a subject without being fully informed as to all the facts relating thereto and as to the purposes for which the information is asked. The opinion should contain a full statement of the conditions under which it applies.

(E) THE ENGINEER'S RELATIONS TO THE ENGINEERING FRATERNITY.

20. The engineer should take an interest in and assist his fellow engineers by exchange of general information and experience, by instruction and similar aid, through the engineering societies or by other means. He should endeavor to protect all reputable engineers from misrepresentation.

21. The engineer should take care that credit for engineering work is attributed to those who, so far as his knowledge of the matter goes, are the real authors of such work.

22. An engineer in responsible charge of work should not permit non-technical persons to overrule his engineering judgments on purely engineering grounds.

(F) AMENDMENTS.

Additions to, or modifications in, this Code may be made by the Board of Directors under the procedure applying to a by-law.

§ 40. Code of Ethics Suggested for The American Institute of Chemical Engineers (1913).—

Purpose of the Code:

To define the rules of professional conduct and ethics for the members of the Institute.

The Institute expects of its members:

1. That in all of their relations, they shall be guided by the highest principles of honor.

2. The upholding before the public at all times of the dignity of the chemical profession generally and the reputation of the Institute, protecting its members from misrepresentation.

3. Personal helpfulness and fraternity between its members and toward the profession generally.

4. The avoidance and discouragement of sensationalism, exaggeration and unwarranted statements. In making the first publication concerning inventions or other chemical advances, they should not be made through the public press, but through chemical societies and technical publications.

5. The refusal to undertake for compensation, work which he believes will be unprofitable to a client without first advising said client as to the improbability of successful results.

6. The upholding of the principle, that unreasonably low charges for professional work tends toward inferior and unreliable work, especially if such charges are set at a low figure for advertising purposes.

7. The refusal to lend their names to any questionable enterprise.

8. Conservatism in all estimates, reports, testimony, etc., especially in connection with the promotion of business enterprises.

9. That they shall not engage in any occupation which is obviously contrary to law or public welfare.

10. When a chemical engineer undertakes for others work in connection with which he may make improvements, inventions, plans, designs or other records, he should enter into a written agreement with regard to their ownership; and when it is subsequently found that such an agreement does not cover a point at issue, the following rules shall apply:

a. If a chemical engineer uses information which is not common knowledge or public property, but which he obtains from a client or employer, the results in the form of plans, designs or other records shall not be regarded as his property, but the property of his client or employer.

b. If a chemical engineer uses only his own knowledge or information or data, which by prior publication or otherwise are public property, and obtains no chemical engineering data from a client or employer except performance specifications or routine information, then the results in the form of inventions, plans, designs or other records should be regarded as the property of the engineer and the client or employer should be entitled to their use only in the case for which the engineer was retained.

c. All work and results accomplished by the chemical engineer in the form of inventions, plans, designs or other records, or outside of the field for which a client or employer has retained him, should be regarded as the chemical engineer's property.

d. When a chemical engineer participates in the building of apparatus from designs supplied him by a client, the designs remain the property of the client and should not be duplicated by the designer or anyone representing him for others without express permission.

e. Chemical engineering data or information which a chemical engineer obtains from his client or employer or which he creates as a result of such information must be considered confidential by the engineer; and while he is justified in using such data or information in his own practice as forming part of his professional experience, its publication without express permission is improper.

f. Designs, data, records and notes made by an employee and referring to his employer's work, should be regarded as his employer's property.

g. A client does not acquire any exclusive right to plans or apparatus made or constructed by a consulting chemical engineer except for the specific case for which they were made.

11. A chemical engineer cannot honorably accept compensation, financial or otherwise, from more than one interested party, without the consent of all parties; and whether consulting, designing, installing or operating, must not accept compensation directly or indirectly from parties dealing with his client or employer.

When called upon to decide on the use of inventions, apparatus, processes, etc., in which he has a financial interest, he should make his status in the matter clearly understood before engagement.

12. The chemical engineer should endeavor at all times to give credit for work to those who, so far as his knowledge goes, are the real authors of such work.

13. Undignified, sensational or misleading advertising should be discouraged.

14. Contracts made by chemical engineers should be subject to the Code of Ethics.

For the administration of this Code of Ethics, a Committee on Ethics shall be appointed by the president holding office at the time of the adoption of this Code, to consist of five members; one appointed for five years, another for four years, another for three years, another for two years, another for one year, and thereafter, the president then holding office shall appoint one member annually to serve for five years and also fill such vacancies as may occur for the unexpired term. Three of these members shall be over forty-five years of age. The committee shall elect its own chairman. The Committee on Ethics shall investigate all complaints submitted to them bearing upon the professional conduct of any member, and after a fair opportunity to be heard has been given to the member involved, shall report its findings to the Council, whose action shall be final.

§ 41. Code of Ethics Adopted by American Society of Civil Engineers, September 2, 1914.—It shall be considered unprofessional and inconsistent with honorable and dignified bearing for any member of the American Society of Civil Engineers:

1. To act for his clients in professional matters otherwise than as a faithful agent or trustee, or to accept any remuneration other than his stated charges for services rendered his clients.

2. To attempt to injure falsely or maliciously, directly or indirectly, the professional reputation, prospects, or business, of another engineer.

3. To attempt to supplant another engineer after definite steps have been taken toward his employment.

4. To compete with another engineer for employment on the basis of professional charges, by reducing his usual charges and in this manner attempting to underbid after being informed of the charges named by another.

5. To review the work of another engineer for the same client, except with the knowledge or consent of such engineer, or unless the connection of such engineer with the work has been terminated.

6. To advertise in self-laudatory language, or in any other manner derogatory to the dignity of the profession.

§ 42. **Questions in Ethics.**—It is reasonably assumed that no one who is interested in the discussion of Ethics would deliberately follow courses of conduct which are clearly and undoubtedly wrong. In many cases, a given course of conduct is so obviously right or wrong that no choice exists for any honorable man: he must pursue a certain line of conduct.

Conduct may vary from such obvious conditions to those in which the questions of right and wrong are so indistinct that opinions may justly vary, concerning the matter which, in extreme cases, may even become simply matters of the individual conscience. The application of ethical rules as adopted by the various engineering societies while obvious in the abstract are not always so obvious in their application; and those applications which may be obvious to the man of affairs may not be apparent to the young man just entering practical life. Certain concrete conditions have therefore been stated, on some of which it seems desirable that the student should express his opinion, and the answers, after being examined, should be discussed and the ethics of the situation explained. By a thoughtful consideration of such questions and a full discussion of the same, the student will gain a more correct view of ethical principles than is possible by the study of a statement of the abstract principles.

1. A young engineer applied for a position that was to last six months, and secured the appointment in active competition with several others. After he had worked at the job for a month, he was offered an opportunity to greatly better his salary in another city. As he was financially irresponsible, he could easily leave without fear of legal action. Should he accept or decline the new offer, and why?

2. Assume that an engineer were an applicant for a certain position and were asked concerning the standing and qualifications of another engineer for the same position, concerning whom he has heard unfavorable reports. Should he give the information he possesses?

3. A young engineer was employed for some years with an engineering firm and acquired considerable experience in their specialty. A party desiring some work done along that line, and hoping to secure the same at a low figure, proposed that the young engineer take up this work at odd times, independently of his employers who, as business was somewhat dull, could spare a part of his services. Was he justified in accepting such work, and why?

4. If an engineer is employed for a portion of his time by a state to examine and pass upon plans for work, on which he is supposed to be expert and over which the state has assumed a certain control, is he justified in

seeking to practice his profession by undertaking to prepare plans and specifications for work along similar lines and within the same state?

5. Should or should not an engineer who has prepared plans and specifications for a piece of work, bid on the same as a contractor, and why?

6. Plans and specifications were prepared by a firm of engineers for a water works system for a small city, and bids were invited. Another engineer, acting with a contractor, made plans for a cheaper system and attempted to secure the contract through their ability to do the work on the cheaper system at a less price than could be made by the other contractors on the official plans. Was the other engineer justified in his conduct, and why?

7. A company which had employed an engineer to prepare plans and specifications for certain work became dissatisfied and uncertain as to the safety of the plans he had proposed. In the absence of the engineer, and without advising him as to their intention, they called in another engineer, explaining in their letter that they desired him to check up the plans and advise them as to their safety and sufficiency. Should the second engineer accept or decline the service, and on what grounds?

8. A second company under similar circumstances, and with the consent of their engineer, called for similar services from another engineer, who accepted and found the works proposed would be perfectly safe but that while it was not obvious, yet he could easily show that a considerable sum of money could be saved and the plant made much more satisfactory by certain minor changes. Such changes in plans would, however, probably reflect to some extent on the engineer of the work, and if the plans were allowed to stand, the possible saving or improvement would never be known. Was it or was it not the duty of the consulting engineer to call the attention of the company to the defect, at the expense of his fellow engineer's reputation?

9. An investigation was made of a contemplated irrigation project and a favorable report was duly submitted by an irrigation engineer to a development company. Another engineer was called to make surveys, prepare plans and specifications and to supervise construction. After considerable progress had been made in the detailed investigations, the engineer became convinced that the preliminary report was greatly in error and that the project could not be a success financially. His opinion was submitted to the development company, and they instructed him to keep his report confidential and to continue the work, with the intention of selling sufficient land to protect themselves from financial loss of the money already invested and perhaps be able to secure a profit. Was the engineer justified or not in continuing the work under such conditions, and why?

10. An engineer, having examined a water power project, reported to his clients that in his opinion the cost of development and other conditions would make the cost of the possible power output too great to make the project financially satisfactory. His opinion was accepted, and the matter was dropped by the client. Later, the same project was taken up by a power company, and the same engineer was asked to take charge of the development. What was his duty in the premises, and why?

11. A manufacturer offered an engineer a commission of ten per cent on all the material that might be used on a contract, provided his special brand of material was specified. If the engineer knew or believed that the material was equal to any similar material on the market, would he be justified in accepting the offer, and why?

12. Would he be so justified if he knew the material was equal to any on the market, and would not cost more than other materials of the same kind?

13. If a similar offer were made to a contractor to specify certain materials with his bid, would he be justified in accepting the same, and why?

14. A company asked two engineers to name the price at which they would agree to prepare plans for a certain piece of work. Each engineer, without knowledge of the other, estimated that the work should reasonably be worth the sum of \$2,000, at which price one of them submitted his proposition. The other, before submitting his proposal, accidentally heard that the same price had been named by his competitor, and being desirous of securing the work, reduced his price to \$1,900. Was he justified in such reduction, and why?

15. If the above work was worth \$2,000 at current professional charges, and an engineer knowing this and without knowledge of the price named by others, was so desirous to secure the work that he was willing to reduce his charges to \$1,500, would he be justified in such reduction, and why?

16. An engineer was about to let a contract for certain expensive machinery. He was very familiar with similar machinery made by a number of first class manufacturers, but was unfamiliar with that made by one concern whose reputation was, he knew, first class. The company, anxious to stand on an equal footing with others, offered to pay all the necessary expenses of the engineer to visit several places where their machines were in use, including a trip to their factory, where a similar machine was under construction. If the engineer desired such information, and could conveniently make the trip, should he accept or decline the invitation, and why?

17. If the engineer made the trip above outlined, either at his own expense or at the expense of the company, and during the trip was invited by the representatives of the company to take various side trips for pleasure and to accept various costly entertainment at the expense of the company's representatives or of the company itself, should he accept or decline, and why?

18. Should an engineer accept, to any extent, minor favors (cigars, theatre tickets, etc.) of a contractor or those who are liable to become contractors on his work, and if so, to what extent?

19. A contractor named a price of \$50,000 for performing a piece of work for a company, for which he was willing to take the Company's notes. The notes, he found, could be discounted at the local bank so as to net the contractor \$49,000. The manager of the company, after consulting with the cashier of the bank, offered through the cashier to award the contractor the contract at \$52,000, provided he would allow the bank a total discount at the bank of \$3,000, in which event the contract would still net the contractor

\$49,000. Should the contractor take the contract under such conditions, and why?

20. If under the above conditions the cashier advised the contractor that the manager was to receive half the discount which the bank made, what should be the contractor's attitude toward the contract, and why?

21. An engineer of reputation was asked by a banking house to take charge of certain engineering work, no price being agreed upon for his salary. He by chance learned that the bankers would not object to a charge of twenty-five per cent in excess of his regular charges. Would he be warranted in increasing his charges beyond his usual basis?

22. In a similar case, a company was so desirous of an engineer's services that they offered him fifty per cent more than his customary charges. He would have been glad to accept the appointment at his regular charges. Was he warranted in accepting the advance?

23. An hydraulic engineer, under an agreement with a village, prepared plans for a water works system. To pay for a part of the work involved, village bonds were issued. The officials of the village asked the engineer if he would assist them in the disposal of the bonds, and he agreed to do so if he conveniently could. He spoke to several bankers, who did not care to buy the bonds, and finally meeting the representative of a bond house, told him of the bonds which the village desired to sell. The bond house purchased these bonds at a price mutually satisfactory to themselves and the village. Afterward the president of the bond company, meeting the engineer, told him that they had bought the bonds at a very satisfactory price, and asked him to call at their office as the bond company desired to give the engineer a check for one hundred dollars. Should the engineer have accepted or rejected the check, and why?

24. A agreed to buy a farm of B for \$5,000, paying \$1,000 cash, and made a written agreement to meet B on a certain date and either complete arrangements by giving a mortgage for the balance or to forfeit the amount paid. Before the date of meeting, B, relying on A's agreement, refused another similar offer. A, on account of sickness, failed to meet at the appointed time, and on account of ignorance failed to be represented by attorney. B was undoubtedly damaged only \$300 or \$400 by failure to sell. By failure to meet his agreement, A legally forfeited his payment of \$1,000. Assuming that A was willing to forfeit a sum equivalent to the actual damages, was B morally warranted in holding A to his agreement?

25. Assume that a body of some five or six men undertake to form a joint stock company in a line of business with which they are familiar. On account of their knowledge and reputation for fair dealing, they secure subscriptions to the stock of the company and organize the same. A board of directors is elected, consisting probably of the original organizers of the company who must also be stockholders. During the early stages of development, the future of the company is more or less uncertain and the probable outcome will be better understood by those closely connected with the management. The right to buy or sell stock is an undoubted legal right which can be exercised by any of the stockholders at any time. Would the

original promoters be justified in selling their stock as soon as the company is organized?

26. Would any of the stockholders be justified in the sale of their stock before the prospects of the company are fully realized?

27. Would any member of the company, be he director or otherwise, who is particularly well informed on the business of the company, be justified in purchasing stock from other members less informed, at less than its fair value by withholding a knowledge of favorable prospects or by unduly deprecating future prospects, and why?

28. Would any stockholder be justified in undertaking to purchase a majority of the stock from other members in order that he might personally sell it at a price greater than its true market value, and thereby place the control of the same in the hands of strangers, and why?

29. Would any stockholder, after acquiring a majority of the stock, be justified in selling said majority to strangers without securing the right of sale to other stockholders of the company, and why?

30. A, who controlled fifty-one per cent of the stock of a corporation, elected himself president of the company and voted himself a salary which will be approved by a court as not excessive but may be more than the work is worth. Is he warranted in using his legal rights to secure an excessive salary?

LITERATURE

Suggested Code of Ethics of the Oregon Society of Engineers. Eng. News, June 12, 1913.

A Proposed Code of Ethics for Engineers. Prepared by council of Am. Soc. Mech. Engrs. Eng. News, Vol. 69, p. 29.

Proposed Code of Ethics for Comment. Jour. W. S. E. Jan. 1916.

Two New Codes of Professional Ethics. Philadelphia Chapter A. I. A.; and Alberta Association of Architects. Eng. Rec., Vol. 60, p. 681.

Professional Ethics for the Mining Engineer. John Hays Hammond. Eng. News, Vol. 60, p. 443.

A Code of Ethics for Architects. Adopted by Boston Chapter A. I. A. Eng. News, Vol. 57, p. 105.

Code of Ethics and Recommended Schedule of Compensation of Maine Society of Civil Engineers. Eng. News, Vol. 70, p. 1231.

Engineering Honors—Presidential Address to American Institute Electrical Engineers, by Schuyler S. Wheeler, Elect. Rev. Vol. 48, p. 968.

Professional Ethics. Abstract of Address to Students of Lehigh University, by Rossiter W. Raymond. Elect. Rev. Vol. 49, p. 64.

Ethics of the Engineering Profession. Victor C. Alderson. Jour. W. S. E. Aug. 1901.

Ethics of Consulting Practice. Staff Article. Eng. News, Nov. 10, 1892, p. 445.

Code of Ethics with Legislative backing for Pennsylvania Society of Engineers, by F. H. Snow. Eng. News, Vol. 61, p. 661.

Strict view of Consulting Engineering. Letter. Eng. News, Vol. 58, p. 617.

Duty of Engineers to the Profession. E. T. Dwelley. Eng. News, Vol. 61, p. 479.

Moral Standards. Responsibility of Technical Colleges, by John Berg. Eng. News, Vol. 55, p. 405.

The Human Side of Engineering. J. C. Wait. Sibley Jour. of Eng. Vol. 28, pp. 20, 68, 94.

CHAPTER V

THE USE OF ENGLISH

§ 43. **The Importance of English.**—The successful engineer must be something more than a skilled mechanic, an artisan or a designer. He must not only be able to make surveys and prepare plans and designs but he must also make reports to his clients or superiors, prepare instructions for his assistants and subordinates, write specifications, prepare agreements, both as a basis for receiving bids and for making contracts; he must originate, lay out and supervise or carry out contract works, and supervise the maintenance and operation of engineering plans. In each case the engineer must be able to explain his plans and proposals so that his reasons and methods will be understood and appreciated.

The ability to prepare clear, logical, forceful and correct English is an asset of great value to the engineer, and frequently means advancement beyond others of equal technical ability but without the ability of correct and proper expression.

Obscure, incorrect and faulty language, used in engineering reports, instructions, contracts and specifications, frequently involves disputes and litigations, with the consequent loss of thousands of dollars, and in some cases misunderstandings which may cause the loss of lives and reputations. Any element in engineering education, the misuse of which may produce such dire results or the correct use of which may bring such great results, is worthy of the most careful consideration and attention.

The command and intelligent use of language is often the best method of conveying to others an appreciation of the knowledge of the engineer and his ability to meet and solve engineering problems. For success the engineer must not only be technically able to solve the engineering problems which come to him for solution, but others must know and appreciate his ability. It is true that the best test of ability is the actual performance of the work in question, but a knowledge of the ability so demonstrated is confined to the clients, employers, friends, colleagues or employees of the engineer, and a wider knowledge of that ability can be secured only by the spoken or written word.

Articles in the technical press or papers before engineering so-

cieties, describing new designs and new work along new and novel lines, when well prepared and presented, extend the acquaintance and reputation of their writer. The preparation of an article or paper, on a subject on which he is particularly well informed, systematizes the engineer's knowledge, gives opportunity for his careful review and personal criticism of his own work, develops his ability, and aids himself more than it does any other individual. When such articles or papers are of real value, they also aid in the advancement of professional knowledge and fulfill a duty every man owes to his profession. When such articles are prepared purely from a selfish motive, for the purpose of advertising and personal advancement, they are usually valueless to the profession and detrimental to the author; but when prepared with the purpose of conveying valuable information and advancing the profession, if well prepared even though the subject be a simple one, they become a valuable asset to the profession and a legitimate aid to individual advancement.

§ 44. **Engineering English.**—Engineering English should and does differ from the English of literature. Fine writing and picturesque language have little place in the writings of the engineer. The language should always be clear, definite and exact; it should often be brief, technical and to the point. It must vary in its character from the English of literature to the English of the law, according to the persons for whom and purposes for which it may be prepared. In general, engineering English must be written with the particular parties in mind for whom it is intended, and their education, training, technical knowledge and point of view must be fully considered.

Engineering writings may be subdivided into several classes, each more or less distinct, but such writings may frequently fall between or within more than one of these classes, and sometimes partake of the character of each.

In general, letters, reports and papers may be written for:

First: Non-technical readers.

Second: Technical readers more or less acquainted with engineering matter but not particularly versed in the special subject treated.

Third: Supervisors and assistants, those specially acquainted with the subject matter treated.

Fourth: Contracts and specifications.

§ 45. **The Hearer or Reader.**—The knowledge and capacity of those to whom written or spoken language is addressed is an important element to be considered in the preparation of articles, reports or ad-

dresses. The statement that "doubling the head of water acting on a given turbine will increase its power more than 2.8 times, because such power will vary with the three-halves power of the head acting," is a perfectly clear statement to the hydraulic engineer but may mean little to a business man, and must be stated in greater detail and with considerable explanation if it becomes necessary or desirable to have the business man understand and appreciate the fact. In such writing technical matters should be explained in clear and simple language, so that the persons for whom it is written will understand the matter involved, the reasons for the plans proposed and the results to be accomplished. There are few technical matters which cannot be made so clear in a properly written paper or report that any good business man can understand them, and failure to prepare such papers that they can be so understood is usually due to a lack of understanding of the matter by the engineer himself. Any engineer has only to attempt to read some advanced work on a subject with which he is unfamiliar to recognize the fact that, while such a work may be perfectly plain to the expert, it is quite meaningless to the novice who must first read elementary works on the subject and acquire the fundamental ideas and the necessary vocabulary before he can comprehend the advanced work.

Papers on technical subjects must therefore be written with the capacity of the reader in view. For the business man, the conclusions are most important, but they should be supported by such a clear discussion of the facts and such a presentation of logical arguments as will appeal to his judgment and common sense. The principles by which the conclusions are reached, and the detailed data to which they apply, are less important but should usually be presented as a basis for the conclusion.

When the paper is prepared for technical readers who have had a certain technical training, and are known to understand certain scientific principles, the matter may be presented in a different form and the special matters described must be so treated as to make them plain to others than the specialist. In such cases the discussion of the data and the principles on which the conclusions rest, becomes the important matter to be considered, and the explanations are needed only of those technical details that are special to the subject and are not commonly understood by the general professional man.

When those addressed are specialists in the matter discussed, the data obtained and the methods of their derivation and investigation become of primary importance. Technical terms properly applied will

add to the clearness of the exposition, and conclusions when drawn must be the obvious deduction from the data and the facts.

In the writing of contracts and specifications, which in the execution of the work must usually be interpreted by men of varying capabilities and which may be and frequently are, subject to the interpretation of the court, the words should be as carefully chosen to express the exact meaning as are the mathematical symbols in an equation. There should be but one interpretation and that the one intended, and the exact meaning of both the common and technical words or terms used and their local or special significance should be thoroughly understood and appreciated. The use of the technical vernacular of the subject treated is desirable when it adds to the clearness of the meaning. Ordinary words and terms must be used with great care, and frequently must be modified and defined so as to assure an exact interpretation of their meaning.

§ 46. **Knowledge of Subject.**—The absolute prerequisite for clear and accurate technical writing is a clear and accurate knowledge of the subject which is to be discussed or described. While this is self-evident, lack of such knowledge is nevertheless an important reason for much and perhaps most of the obscurity in reports, technical papers and specifications. If a specification must be prepared or a technical detail described which is imperfectly understood by the writer, how then can it be made clear to others? It is impossible to convey a true idea which is not possessed by the writer, and the idea conveyed can never be clearer than the writer's understanding of the matter described.

It is evident that the engineer who wrote the specifications for the measurement of earth in embankments discussed in Section 51, did not fully and clearly understand or appreciate the element of shrinkage as affecting the measurement of earth fills and entirely failed to conceive the conditions under which such measurements might have been made. If these subjects had been understood, the necessity of an appeal to the court would have been avoided.

Accurate and complete knowledge requires study, application, effort and reflection. These, technical writers frequently fail to exercise, either from indolence, carelessness or lack of time, any one of which is a reason for obscure language, but no one of which can be considered as a valid excuse for such language.

A knowledge of spelling, punctuation, grammar, rhetoric and composition, and even a broad experience in the writing of tech-

nical English will not supply lack of knowledge of the subject matter. While these subjects are necessary elements of good English, and are indispensable for clear and exact English, and while the principles of rhetoric and composition are desirable and even essential for the best productions, they are all secondary to the idea or ideas which it is desired to convey. Failure to possess or to exercise a knowledge of these subjects shows lack of cultivation and is undesirable, and in important cases highly objectionable. The exercise of such knowledge is desirable as a means to an end, but it cannot, without collateral knowledge of the subject matter, attain that end.

There are few men thoroughly versed in their subject and fully acquainted with all its details, who cannot present such subject, orally at least, in a clear and usually interesting manner. Even though their grammar be defective, their sentences imperfect, and their entire presentation poorly arranged, yet their knowledge is apparent and their efforts are appreciated. The combination of both knowledge and literary ability is necessary for the presentation of technical matter in clear, concise and correct language, and logical form naturally increases the ease with which the hearer can follow the argument and comprehend the ideas. But no literary ability, no flights of rhetoric, no elegance of diction or practice in delivery or presentation, can replace or supply the lack of knowledge of the subject or convince the intelligent hearer that there is more than empty sound in such an address.

In written papers, adequate presentation, without some knowledge of the principles of literary composition, becomes more difficult; but the principle remains that knowledge is the prime essential and the one element without which even partial success is impossible.

Whatever the subject may be and whatever the object of the paper which is to be prepared, it can be successful only when based on a sound, clear, exact and detailed knowledge of the subject considered. With such a knowledge, the preparation of sentences, paragraphs and entire papers of a form and substance which can be clearly understood, becomes largely a matter of care and practice. With something to say or to explain, which is clearly understood by the writer, and with the capacity of the reader kept fully in mind, any technically educated man can with care and diligence soon acquire the ability to write English.

Primarily therefore, for technical writing of every description, the essential feature is to have the subject well and thoroughly understood, to have something to say, and then to say it in the simplest, plainest, clearest language of which the writer is capable, keeping clearly in mind the capacity of the readers for whom the matter is intended.

Knowledge of the subject is fundamental to success, and indispensable for clear technical exposition; and secondary, but yet very important, comes a knowledge of spelling, punctuation, grammar, rhetoric, composition, and the meaning of words both common and technical.

§ 47. **Logical Arrangement.**—While a clear statement of facts or requirements is essential to convey the ideas and meaning desired, when the matter discussed requires considerable space for its full consideration, the logical arrangement of the material becomes hardly less important.

All technical writings are intended to convey to the reader a knowledge of what the writer knows or desires, in such a manner that he shall clearly understand the subject discussed or the requirements described, as completely as necessary or desirable for the purpose in view. The subject should be considered with this end in view. It should be outlined in general and then discussed in detail, and the discussion should proceed logically from the fundamental and essential features to those that are subordinate and less important.

The subject should first be analyzed and its fundamental and essential features separated and arranged in logical sequence. Each feature should be further considered, and the subordinate but essential qualifying factors arranged in a similar manner. When the entire subject has been treated in this manner, and an outline has been prepared, the preparation of the written matter can then proceed.

The subject should first be discussed in a general way so as to give at once a concrete conception of the matter to be treated. Following this each feature can be taken up in the order determined and discussed as fully as its importance demands. The main ideas underlying the treatment should be: first, the arrangement of the entire subject in logical order both as regards main features and subordinate factors; and second, the discussion of each feature and each subordinate factor in a connected manner but at the same

time so distinctly and separately as to accurately define to the mind of the reader its relative importance and its modifying effect on the entire subject.

One main idea and one only should be developed in a paragraph, and the subject may and should be divided into such sections and subsections and such chapters or other subdivisions as may be necessary to accomplish the clear and logical presentation of the subject. As the subject is distinct from other subjects, so should the main divisions be separate and distinct from each other, and each should be devoted to the complete consideration of that particular feature to which it is assigned. In the same manner, each subdivision should be devoted exclusively to that one of the principal features of the main subject which is discussed therein, and each subordinate idea or qualifying influence should be assigned a section or a paragraph, as its importance warrants.

With due study, reflection and practice, the development of a subject along the lines indicated is readily accomplished and if carried out with reasonable intelligence, will result in a clear exposition of the entire subject.

§ 48. **The Outline.**—The general idea of the construction of the outline which should precede the writing of any extended technical paper, can be readily acquired by the examination of the table of contents of any well written technical book or by the study of any well prepared specifications. Chapter VII of this book gives a brief analysis of the whole subject of law, and Chapter IX a more complete analysis of the subject of contracts. The latter subject is but a minor subdivision of the former, but it would require several volumes for its complete consideration.

In the preparation of an outline it must be understood that the purpose for which the paper is prepared may not require complete or even a well balanced treatment of the subject. The purpose of the paper may be to develop and emphasize some particular phases of the subject that are most important for the ends in view. These must receive more elaborate treatment, and matters of minor importance must be subordinated to the general purpose and more briefly treated or altogether ignored, as their importance, relative to the main object, warrants.

What ideas are to be developed, what facts are to be presented, and what order of presentation will be the best and most logical and will most easily convey the meaning which it is desired to

impress on the reader, are matters which depend on the purpose for which the paper is prepared and the readers to whom it will be presented. In general, the purpose and the reader must be kept continuously in mind, and all diversions which will tend to obscure the main object of the paper or distract the attention of the reader from that object, must be avoided.

The outline should be regarded only as a means to an end, and should be changed or modified as the necessity for alteration may develop during the preparation of the paper. Facts and illustrations, which it may at first seem desirable to utilize, may be found, during the preparation of the paper, not to yield to satisfactory treatment, and others may be substituted to advantage. In the first attempts at the preparation of such papers it may reasonably be expected that the development of the subject will frequently make desirable an entire reconstruction and rearrangement of the outline. The best results and ultimate facility in the preparation of technical papers can be secured only by willingness on the part of the writer entirely to rearrange and rewrite his paper as often as he can recognize the opportunity for material betterments.

The actual preparation of an outline may be preceded to advantage by the analysis of existing papers on subjects similar to that under consideration. The papers for such study should be selected from the best available sources. From the analysis so made, an outline should be prepared which will exhibit at a glance the plan of construction of the paper selected for study. Such an analytical outline will give the student a clear idea of the basis presumably used by the best writers in the preparation of their papers and will serve as a guide to the preparation of an outline for the subject at hand. Valuable suggestions and examples along this line may be found in the following chapters on specifications, and in various books on English composition to which references are given at the end of this chapter.

§ 49. **Style.**—Technical men commonly possess an unwholesome disrespect for literary ability. It is often assumed by them that they are men of action and not of words, and that therefore the devotion of their attention to the correct principles and methods of literary expression is superfluous and non-essential, and rather to be neglected than cultivated. The education of technical men is largely scientific, and precision and efficiency are among the most important principles of their training. Such education is not complete

until the value of literary ability is appreciated. Let the technical man be scientific in his use of language as well as in the development of his plans. Let him apply these principles in his writing as well as in his work. Let the sequence of his thoughts be logical and his expressions precise in order that he may secure the greatest efficiency in conveying by the language used clear comprehension of the ideas, facts, opinions or requirements that he desires to impress on his readers. In this way only can he produce good technical letters, reports, papers and specifications.

The fundamental principle of expression either written or spoken is to secure efficiency in the comprehension of ideas by the person addressed, with the least possible mental effort. The engineer recognizes that in machinery, simplicity in design and the proper arrangements of parts are necessary for efficiency in power transmission. Complication in parts, unnecessary transformation and inconvenient arrangement result in needless loss of energy, and all losses in the machinery reduce the amount of energy which can be delivered for useful work, and such losses must therefore be reduced as far as possible.

The same principles apply in the use of language. The mental power of the reader is to be utilized for the transmission of ideas by the mechanism of words. The amount of mental energy available for the purpose is limited. With this energy the reader must recognize and interpret the words used, arrange and combine the images suggested, and finally must realize the thoughts conveyed. If the language is confused, verbose, or involved, more mental energy is used up in recognizing the words and interpreting them, and the less is available for the understanding of the thought which it is desired to convey.¹ All losses in the mental energy of the reader must therefore be reduced to a minimum to secure the best results.

Simplicity in language, when practicable, results in the highest efficiency in comprehension. A gesture or an exclamation frequently conveys a more accurate idea of the thought or feelings than a sentence or paragraph, and the spoken word is more efficient than the written.

The spoken word is received direct, with the advantage of personal expression, and often with a community of knowledge between the speaker and the persons addressed. The literary form

¹ Spencer, "The Philosophy of Style."

of oral expression, while important in all cases and of great importance in the formal presentation of technical matters, is of less importance than when the same matter is presented in written or printed form. In the latter cases the personal element is lacking, and the meaning must be drawn solely from the language used, and everything that can be done to make the subject matter clear, accurate and attractive is essential to the best results. The careful choice of words, the accurate use of technical terms, correct grammatical construction, logical arrangement of ideas, clear methods of expression, the presentation of the matter in an attractive manner, are all desirable to secure and hold the attention of the reader and to convey the meaning clearly. Poor spelling, improper punctuation, ungrammatical construction and involved language draw the attention to subordinate matters and lead the reader to surmise that the conclusions presented may be as erroneous as the form in which they appear.

The subject matter should not be sacrificed to the style, but the style should be utilized to develop and illuminate the subject matter. Technical matters may often be dry and, to other than technical men, uninteresting and obscure. The careful choice of words simplifies the subject, clarifies the idea and crystallizes the thought in the mind of the reader. The careful selection of expressions and the adaptation of a suitable literary style attract and retain the attention, simplify the subject matter, and often interest the reader in subjects of which he would otherwise weary.

There are few needs for elaborate rhetorical effort in technical writing; such efforts, even if they do not appear absurd, attract attention to the manner of expression rather than to the matter expressed, and hence are objectionable. The language should be brief and exact and the words should be simple but carefully chosen. The point of view and the extent of knowledge of the reader must determine the degree of simplicity with which the subject must be treated. Unessential and meaningless generalities should be eliminated, for they tend toward obscurity and the diversion of the reader's attention from the main subject on which his thoughts should be concentrated.

§ 50. **The Choice of Words.**—Accuracy of expression demands a careful choice of words. Words are never exactly synonymous in their meaning. Even when words are derived from foreign words of exactly synonymous meaning, they are adapted in the

English to express ideas more or less different. In the growth and development of language words often acquire other special meanings perhaps quite foreign to that conveyed by the original signification. These changes grow from the original meanings based on physical likeness, association, similarity of relation, use of a part for the whole, adaptation of the mental for the physical, and idiomatic metaphors.

Take for example the changes and extension in meaning of the common word *head*:²

1. The original physical meaning: Head.
2. From physical likeness: The *head* of a river; or the consummation of a development to come to a *head*.
3. From association: The *head* of a bed.
4. Similarity of relation: The *head* of a business.
5. The part for the whole: A hundred *head* of horses.
6. Mental for physical: A clear *head*.
7. Metaphorical: Over *head* in debt. To make *head* against obstacles.

Words, from some special and peculiar association, sometimes also acquire a meaning distinctly foreign to their ordinary signification. For example, the term *expert* means one who is especially well versed in any matter requiring a special training to qualify a person to understand or act intelligently in such matter. On account of the abuse of the term, and the wrongful acts of some parties claiming this title, the term is sometimes satirically used as a term of scorn or reproach.

Most common words have numerous meanings which are often difficult to differentiate even when properly used. Frequently such meanings are unauthorized by good usage, and such use should be discouraged and discountenanced as it obscures the language and makes necessary an accurate definition of the special meaning in which it is to be understood in important papers.

Take for example the following thirteen uses of the word *rock* and the difficulties attendant on its specific use in the limited sense as further discussed in Chapter XVII. It may have meanings in accordance with its various uses as follows:

Geologically: Any mass of mineral matter, in its natural bed of which the earth's crust is composed, whether solid or fragmentary.

Popular: 1. A stone of any size, even a pebble.

² See Anderson's "Study of English Words."

2. A mass of indurated stone, forming a promontory or cliff.
3. Natural crystals or candy in crystalline form.

Figurative: 1. A foundation, support or refuge.

2. A source of peril.

Technical: 1. Indurated formation of different degrees of hardness.³

2. A kind of soap.
3. A kind of hard cheese.
4. Ore (used among the Michigan copper mines).⁴

Slang: 1. Money or wealth.

2. Rough, uncouth (feelings or appearance).

Association: Rock fish—rock dove.

The term "watershed" formerly meant only "the line of division between two adjacent drainage areas." As such a line defines the "drainage area" itself, the term has been gradually applied to "the whole region which contributes to the supply of a river or lake," that is to the drainage area, and this definition of "water shed" is now recognized as good usage. The term "catchment area" is also sometimes used synonymously with "drainage area." "Drainage area" or "catchment area" has only a single meaning and cannot be misunderstood. They should therefore be used in preference to the more indefinite term "watershed." "Drainage area," being the more common term is usually more appropriate when used for non-technical readers.

The above examples will indicate something of the difficulties which will be encountered in conveying ideas without a careful study and discrimination in the use of words. No attempt to consider this subject in particular is possible in the limits of this chapter, but a warning of the difficulties to be encountered in the selection and use of words, terms and clauses should be sufficient to encourage the study in the lines suggested by means of the references given at the end of this chapter.

As words are used to convey ideas, those words should be chosen which both accurately express the idea to be conveyed and are most familiar to those to whom the words are addressed.

Most of the English words in constant daily use, and most intimately connected with the personal and familiar affairs of life, are of Saxon origin. They are understood more quickly and move the hearer more forcibly than similar words of Latin origin. Latin words,

³ See also secs. 205, 206.

⁴ A misleading and unwarranted use of the word.

however, are more elaborate, more scholarly, and more exact. Words of Latin origin must be used by the technologist in the scientific discussion of technical subjects, on account of their greater exactness, and the suggestions associated with such scientific terms. The selection of words of Saxon or Latin origin for use in technical papers would therefore depend on the subject discussed, the object of the writer, and the technical education of the reader. In reports and papers intended to explain technical matters to the public, or to non-technical clients, Latin terms should be avoided and simple Saxon words used so far as possible. When technical matters are presented to technical readers, the use of Latin terms is not only admissible but absolutely essential to clear exposition.

Simplicity in understanding is not always assured by simplicity in language. The more exact terms are always preferable if the reader can easily comprehend their meaning.

§ 51. **The Precise Use of Words.**—The habit of the careless use of words is unfortunately acquired by almost every person with his early use of language. In ordinary intercourse, the subject discussed is often so familiar and the conditions so well known to both parties to the conversation that the meaning of the language used is often quite obvious, even if the words used do not express the exact meaning which the speaker intends to convey. When, however, the subject is unfamiliar, and the ideas to be conveyed are intricate or involved, the words must be used with precision or the meaning to be conveyed is obscured, distorted or entirely lost. Outside of the legal profession, there is no profession in which careful discrimination in the use of words is so important as in the profession of engineering and the closely related profession of architecture. The records of the courts are full of cases involving the interpretation of the meaning of words. In 1855 a case was taken into court on account of a contract in which the words "road" and "track" were indiscriminately used. A railroad was to be built between certain termini, according to certain specifications, and at an agreed price per mile. The question at issue involved the determination of whether the price was per mile of track, including main track, side tracks, etc., or per mile of roadbed. The latter interpretation was applied, apparently for the reason that the contractor had accepted monthly payments on that basis without any claim for side tracks and turnouts.⁵

⁵ See Wait, *Engineering and Architectural Jurisprudence*, sec. 601.

Another legal discussion, which illustrates the necessity for precise language in order that only a single interpretation may be possible, was handed down in a case that came up in the construction of the Northern Pacific Railroad.⁶ The dispute arose over the amount of earth excavated from certain ditches and used in an embankment. The specifications apparently read approximately as follows:⁷

"Earth will be measured in excavation; but when earth is taken from borrow pits or ditches not easily measured, the earth may be measured in embankment, in which case an allowance of 10 per cent for shrinkage will be made."

While at first reading this specification appears plain and without ambiguity, it is in reality capable of two interpretations, dependent upon whether the 10 per cent allowance for shrinkage is applied to the cut or fill. In the case in question, an embankment of 100,000 cubic yards of earth was made from two cuts that measured 60,000 cubic yards, and the remainder from ditches that were not measured. As earth work is commonly estimated to shrink 10 per cent, one cubic yard of cut would shrink to .9 cubic yard of fill. On this basis 100,000 cubic yards of fill must have required 111,111 cubic yards of cut, and the amount due the contractor would be:

100,000 ÷ .9	111,111 cu. yds.
From cuts	60,000 cu. yds.
From ditches	51,111 cu. yds.

The contractor, however, estimated the amount due him on the basis that the shrinkage allowance applied to the fill, his computation being as follows:

110 per cent x 100,000	110,000 cu. yds.
From cuts	60,000 cu. yds.
From ditches	50,000 cu. yds.

The engineer and the company, on the other hand, while differing between themselves, entirely misinterpreted the basis on which the shrinkage should be measured, and computed the yardage as follows:

The engineer's computation:

Total yardage	100,000 cu. yds.
From cuts	60,000 cu. yds.
	90%) 40,000
From ditches	44,444 cu. yds.

⁶ See Wait, *Engineering and Architectural Jurisprudence*, sec. 601.

⁷ Eng. News Sup., Vol. 51, p. 129.

The company's computation:

Total yardage	100,000 cu. yds.
From cuts	60,000 cu. yds.

40,000
110%

From ditches	44,000 cu. yds.
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The lower court sustained the estimate of the company, which, regardless of the interpretation of the shrinkage percentage, was the farthest from the truth.

The illustration shows not only the necessity of the careful use of words, but illustrates the further fact that engineers are liable to errors in their findings, and sometimes fail to understand the basic principle that underlies their problem, and that courts must be furnished with carefully prepared expert testimony if they are to reach substantial justice in their findings. If this specification had been so written that there was only one possible way of interpretation, there would have been no legal proceedings, for only one method of computation would have been possible. See Sec. 209.

§ 52. Punctuation and the Arrangement of Words in a Sentence.—It is obvious that the meaning of an expression or sentence is largely controlled by the arrangement of words and by the emphasis that is given in their oral expression. In writing, the emphasis to be observed must be implied by the arrangement or indicated by punctuation. An accurate understanding of the meaning of the language used can therefore be assured only by care in the selection of words and in their arrangement or by punctuation or both. There is perhaps a tendency at the present time to eliminate all punctuation that is not essential to determine the meaning of a sentence, and in many cases with the proper arrangement of words the meaning will remain clear without punctuation. This tendency often results in the omission of punctuation where it is needed to give the meaning which it is desired to convey. When punctuation is omitted, though needed in order to assure the proper meaning of the sentence, it must be assumed by the reader and may consequently be improperly assumed. A recent heading of a newspaper article appeared without punctuation as follows:

"Indiana permits pure food only at fairs."

In this sentence the meaning must be supplied by an assumption of the punctuation and will be quite different if the comma is applied after or before the word "only."

"Indiana permits pure food only, at fairs."

"Indiana permits pure food, only at fairs."

The true meaning without punctuation would be assured by the better arrangement of the words:

"Indiana permits only pure food at fairs."

Only a proper arrangement of the words or proper punctuation will make clear the meaning of this sentence.

In many cases the meaning of a sentence will be entirely changed by the change in punctuation or by its assumption in an unpunctuated sentence, as for example:

"Woman, without her, man would be a savage."

"Woman without her man, would be a savage."

A rearrangement and slight change in the wording would in this case assure an accurate understanding of the meaning to be conveyed without punctuation, as for example:

"Man would be a savage without woman," or

"Man without woman would be a savage."

It is not our purpose to discuss the principles of punctuation or its customary use, but only to call attention to the necessity of correct application, the confusion resulting from its improper use, and the uncertainties resulting from its omission.

§ 53. **The Vocabulary.**—It is important that the engineer should acquire a technical vocabulary and a knowledge of the vernacular of the business in which he is employed or with which he may be associated. Otherwise he will not be able to understand, give instructions, or furnish explanation of technical or trade details. Such information is also necessary in the preparation of specifications and technical reports and papers for technical readers. Scientific and technical terms and the familiar and special trade terms and trade vernacular simplify explanations covering materials, operation and details of construction, and are absolutely necessary for reasonable facility in business transactions. Mr. John C. Wait, a prominent engineering attorney of New York City, in a paper on the subject of engineering vernacular, gives the following notes taken by one of his assistants, concerning certain conditions on which the contractor on the work desired advice.

In the first case, a bridge contractor stated that:

"A traveler was on the lower cord of the approach span of the Williamsburgh Bridge and was sustained by four guys. Each guy was held fast by two dogs, after passing through an opening in the tail piece. Tony, an Italian, had just been sent out and had given two of the dogs a fresh bite on the longest guy, when they let loose, one of the guys slipped, and the

traveler tipped over and threw the counter-weights into the air and they went down on the street below and killed a man."

The contractor wanted to know if he was liable.

In the second case, a mason contractor stated:

"He had been employed to remodel a masonry dam and a Flemish bond was first required of him, but the engineer wanted a better bond and insisted on having greater security. The engineer insisted that the stretchers should be bonded by an overlap of the bed by not less than fifteen inches, and that every alternate course of the dam should be tied with a header. He also required the length of each stretcher to be three times the rise, and the depth of the header in the backing equal to three times the rise; that the rock face of the remodeled dam should be draft-lined, the molded face should be 6-cut, the base pean hammered and the water-table the run of the quarry; the arch rings were to be bush-hammered, close-jointed and grouted, all to be battered and broken ashlar; that the overflow should be in 12-inch risers and treads, and the steps rough-cut, all interior spaces to be thoroughly grouted with neat cement."

The contractor desired to know if he had any redress.

It is doubtful whether many young engineering graduates would understand the conditions outlined much better than did the young lawyer in Mr. Wait's office, yet the conditions are quite clearly defined if the terms used are understood.

The best method of acquiring a technical vocabulary is the direct study of the words and terms used in any special vocation or business when such information is accessible. The reading of the various technical papers and the proceedings of the various societies which cover or include the special subject in which information is desired will often furnish valuable additions to the vocabulary. The use of standard dictionaries is of little value in this study as the definitions given are too general. Some valuable work is being done by various technical societies in the definition of technical terms and the establishment of uniform practice and this work should be closely followed.

LITERATURE

- The Theory and Practice of Technical Writing. S. C. Earle. The Macmillan Co.
- Handbook of English for Engineers. W. O. Sypherd. Scott, Foresman & Co.
- A Guide to Technical Writing. T. A. Rickard. Mining and Scientific Press
- Note-Taking. S. S. Seward, Jr. Allyn & Bacon.
- The Art of Writing and Speaking the English Language. (6 small vols.) Sherwin Cody.

- Effective Business Letters. A. H. Gardner. The Ronald Press Co.
 Putnam's Correspondence Handbook. Eleanore Banks. G. P. Putnam's Sons.
 Conservation of English Speech. J. F. Ferrald. Funk & Wagnalls Co.
 Handbook of Composition. E. C. Mollet. D. C. Heath & Co.
 The Correct Word. J. T. Baker. Correct English Pub. Co.
 Errors in English. F. H. Vizetelly. Funk & Wagnalls Co.
 The Essentials of Composition and Rhetoric. A. H. Espensshade. D. C. Heath Co.
 A Study of English Words. J. M. Anderson. Am. Book Co.
 Expository Writing. M. G. Fulton. The Macmillan Co.
 Elements of English Composition. Gardner, Kittredge and Arnold. Ginn & Co.
 English Composition. Barrett Wendell. Chas. Scribner's Sons.
 Essentials of Exposition and Argument. W. F. Foster. Houghton, Mifflin Co.
 English Prose Composition. Edward Fulton. Henry Holt & Co.
 Words and Their Uses. R. G. White. Houghton, Mifflin Co.
 Every-Day English. R. G. White. Houghton, Mifflin Co.
 Soule's Dictionary of English Synonyms. G. H. Howison. Little Brown & Co.
 English Synonyms, Antonyms and Prepositions. J. C. Ferrald. Funk & Wagnalls Co.
 Crabb's English Synonyms. George Crabb. Harper & Brothers.
 Standard Thesaurus of English Words and Phrases. C. V. S. Mawson. The Kelmscott Society.
 Putnam's Word Book. L. A. Fleming. G. P. Putnam's Sons.
 The Theory and Practice of Technical Writing. S. C. Earle. The Macmillan Co.
 Handbook of English for Engineers. W. O. Sypherd. Scott, Foresman & Co.
 Conservation of English Speech. J. F. Ferrald. Funk & Wagnalls Co.
 Handbook of Composition. E. C. Mollet. D. C. Heath & Co.
 The Correct Word. J. T. Baker. Correct English Pub. Co.
 Errors in English. F. H. Vizetelly. Funk & Wagnalls Co.
 The Essentials of Composition and Rhetoric. A. H. Espensshade. D. C. Heath Co.
 A Study of English Words. J. M. Anderson. Am. Book Co.
 Expository Writing. M. G. Fulton. The Macmillan Co.
 Elements of English Composition. Gardner, Kittredge and Arnold. Ginn & Co.
 English Composition. Barrett Wendell. Chas. Scribner's Sons.
 Essentials of Exposition and Argument. W. F. Foster, Houghton, Mifflin Co.
 English Prose Composition. Edward Fulton. Henry Holt & Co.
 Words and Their Uses. R. G. White. Houghton, Mifflin Co.
 Every-Day English. R. G. White. Houghton, Mifflin Co.
 Soule's Dictionary of English Synonyms. G. H. Howison. Little Brown & Co.

English Synonyms, Antonyms and Prepositions. J. C. Ferrald. Funk & Wagnalls Co.

Crabb's English Synonyms. George Crabb. Harper & Brothers.

Standard Thesaurus of English Words and Phrases. C. V. S. Mawson. The Kelmscott Society.

Putnam's Word Book. L. A. Fleming. G. P. Putnam's Sons.

Faults of Technical Literature, by R. Fleming. Eng. News, Vol. 74, p. 548.

The Authors Part in the Technic of Book Making. Editorial, Eng. News Supplement, July 13, 1905.

Engineering English. Discusses desirability of training technical students in use of English. Harry R. O'Brien. Eng. News, Vol. 70, p. 914.

New Standards in Engineering Literature. Discussion of needs for greater care in preparation of published matter. Staff Article, Eng. News, Vol. 56, p. 688.

The Making of Literature for Engineers. Discusses necessity for technical literature and the standards of journalism. Charles Whiting Baker. Eng. News Supplement, Apr. 16, 1908.

English Language and the Engineering Student. Eng. News Sup. July 16, 1903.

A Guide to Technical Writing. T. A. Rickard. Mining and Scientific Press.

Note-taking. S. S. Seward, J. Allyn & Bacon.

The Art of Writing and Speaking the English Language. (6 small vols.) Sherwin Cody.

Literary Style in Technical Writings. Discussion of desirability of presenting technical subjects in a readable manner. Editorial, Eng. News Supplement, Sept. 15, 1910.

Precision in the use of Words. Editorial, Eng. News Supplement, Dec. 3, 1903.

CHAPTER VI

LETTERS AND REPORTS

§ 54. **Importance of Properly Written Letters.**—Usually the first introduction of the engineer or architect to those whom he desires employment comes through the spoken or written word, and a clear and concise statement of his claims to employment, of his education and previous experience, presented in proper form, is an important element in securing the position he desires. A letter poorly written, poorly worded, misspelled, ungrammatical, improperly punctuated and illogically arranged, marks the writer as careless and more or less ignorant and is an unfortunate introduction.

Personality in a personal application may to some extent overcome ungrammatical and incorrect language, and at least the spoken word leaves no lasting record behind; but a poorly written letter may pass from hand to hand and may leave an enduring record of incompetency.

In later business and professional life, the art of letter writing is of no less importance. The impression conveyed by a clear, concise and properly arranged letter is of great advantage, and business transactions are greatly facilitated by such letter. Much time is often lost through careless letter writing where the failure plainly to state the facts which it is desired to communicate, necessitates a request for explanation or further information.

§ 55. **Business Letters.**—In the writing of business letters, certain more or less formal methods of arrangement have been generally adopted and the use of such arrangement is desirable as showing the familiarity of the writer with good usage. The principal requirements for the proper preparation of a business letter are as follows:

Heading.—The address in the heading should always be sufficiently complete for postal purposes. If a street and house number are necessary, they should precede the name of the city, but the date should come afterward and not before. It is desirable to use the name, not the number of the month; the number of the day of the month, and the complete number for the year. The day of the month and house number should be Arabic numerals, but street numbers if less than one hundred are usually spelled out.

Abbreviations.—While for formal letters it is perhaps more dignified to avoid abbreviations in both the heading and salutation of the letter and in addressing the envelope, it is both permissible and desirable to use such abbreviations in business letters for the name of the months and of the states.

Address.—The salutation address may omit the street and house number, but the name of the city and state should always be included in formal letters and the title “Mr.,” “Messrs.,” etc., should always be used as a matter of courtesy.

Salutation.—Use the form “Dear Sir,” not “My Dear Mr. ——,” unless you are quite intimately acquainted with the party to whom the letter is written. In official communications and letters to Government officials, use the still more formal “Sir.”

Subject Heading.—The use of a subject heading in all business letters is very desirable. Its use in applications for employment is advised as it gives the idea of familiarity with business methods. It should be placed at the right and just above the body of the letter, as follows: “Application for Employment.” For examples of the proper form of business letters see Section 59.

§ 56. **Suggestions Concerning Letters of Application for Employment.**—Great care should be used in writing letters of application for employment. The handwriting shows character and is often required in applications for positions. For this reason such letters should be written, not typewritten, unless unfortunately the handwriting is so poor as to make such a form of application hopeless.

It should be borne in mind that the prospective employer probably has no knowledge of the applicant other than that afforded by the letter. The success of the applicant will depend upon his creating a favorable impression and to this end neatness, proper form, good grammar, correct spelling, definiteness of expression and good composition are highly important. The qualifications of the applicant should be presented fully, clearly, concisely and logically.

The paper used should be of commercial note size, and of good quality. Scrap paper or paper punched or specially ruled for technical work, is unsuitable. The writing should not be crowded and should be properly centered on the sheet.

The young engineer, especially when just graduated, should not be too ambitious in his application for work and should not limit too closely the character of work for which he applies. Unless he has had considerable experience, he should not apply for a

position as a "civil engineer," "electrical engineer," etc., but for a "position" or a "position as assistant." He may give an idea of the work which most interests him, but should express his willingness to accept any reasonable position as he is seldom qualified or in position to command any important place on an engineering staff.

When the young engineer has done previous work, his former salary may be mentioned, but otherwise the matter of salary should be left to a later communication. He should not give the idea that the question of salary is first in his mind.

§ 57. **Important Suggestions.**—Economy and efficiency in the use of language are essential in letter writing as in other engineering writing. After writing a sentence:

(1) See how many words can be omitted or changed, leaving the meaning clearer and stronger.

(2) See how the same idea can be expressed in better and clearer terms.

Do not write:

"I wish herewith to enter my application for"

"I hereby wish to make application for"

"Allow me, respectfully, to offer myself as an applicant for"

"I would like to enter an application for"

"I wish to take this means of applying to you for"

Instead of the above write:

"I respectfully apply for"

Statements should not be too blunt. It is unnecessary to write: "I have not had any practical experience." Write preferably: "My knowledge and experience are limited to my work at the university."

References.—Avoid, "For references I suggest the following" or "Please refer to the following:" Use instead "I respectfully refer you to ——." Reference to a school college or university is improper. Refer to some particular teacher, professor or official of such institution. Reference to a bank is proper for financial standing. For personal standing, the name and position of an official should be given.

In personal applications for work, open letters of recommendation are of little weight. They are, of course, favorable or they would not have been written or presented. The employer usually prefers a personal and private letter addressed to himself from some one of standing or reputation. He has probably written too many general open letters

of recommendation himself to have much confidence in them. Most positions are secured by personal applications, and too much must not be expected from general letters of application although they frequently result in uncovering vacancies for which personal application should usually be made.

Finally.—The letter should be reread after it has been written to see that no essential word or words have been omitted or misspelled and to see that it is signed. Omitted words and especially an omitted signature, show carelessness that is not a good recommendation for a position.

Further details of the general subject of letter writing are given in the following discussions.

§ 58. **The Employer's Viewpoint.**—Mr. C. A. Bock, Secretary of the Morgan Engineering Company, as a result of an examination of over 3,000 letters of application, embodied his views in a letter that is so pertinent that it is here abstracted at considerable length. (See Eng. News, Vol. 76, p. 258.)

"In the applications from college graduates common faults are poor spelling, careless handwriting, lack of definiteness, poor composition and a generally slovenly appearance. While it is not to be expected that a young and inexperienced man will turn out a faultless composition, it is assumed that if he has potential ability he will not exhibit gross carelessness in a letter of this kind. The habit of error and carelessness is particularly disqualifying for engineering work and will not be tolerated by competent engineers.

"The applicant's greatest difficulty probably arises from his inability to appreciate the employer's view point. He should remember that all the employer has to judge from is just what he sees in the letter. If he sees poor writing, spelling and diction, lack of definite information or meager information, presented in a disorderly manner, it is but reasonable to expect that he will form an indifferent opinion of the writer's ability. It is usually desired that the first letter give full information as to the applicant's qualifications. While often a number of letters may be exchanged before the man is engaged, the first letter makes the greatest impression.

"The applicant must ask himself just what are the things that the employer would want to know about the man he wishes to employ. He must analyze the requirements of the opening he wishes to fill and then set forth his qualifications logically, in the order of their importance. This does not mean that qualifications should be manufactured to meet the requirements, nor that he should unduly enlarge upon his previous experience. Such expedients generally are very easily detected and reflect little credit on the man who resorts to them.

"The letter should be concise and come to the essentials without prelude, but must not be brief to the point of sacrificing pertinent information. A

common mistake is that of devoting a long paragraph to stating that "I realize that a large number of applications will doubtless be received and that it will require a great deal of your time to read through them all, and it will probably be very difficult to decide," etc. Simple, direct statements, neatly written in well-balanced sentences, will nearly always make a favorable impression, and much can be accomplished by logical paragraphing.

"A very short letter is not likely to accomplish much for the writer unless he is already personally known. Single-sentence letters or brief inquiries asking detailed information concerning the vacancy and telling nothing of the writer's qualifications at once give the impression that he would be more interested in personal advantages than in serving his employer and that he is not over-anxious to secure the position.

* * * "Many capable and deserving men, do not realize the bearing that the writing of an application may have upon their prospects. Men of indifferent ability frequently secure positions simply through a favorable presentation of their supposed fitness, and it is often the case, especially with younger men, that the one who makes the neatest and best presentation of his qualifications secures the position rather than the one who has greater ability, but lacks the faculty of presenting his qualifications.

"In replying to an advertisement or to a letter, any requests for certain items of information should be fully complied with. A point illustrating this requirement which has repeatedly come to the writer's observation is the fact the draftsmen, when asked for a small sample of their lettering, seem to think it necessary to submit several large bulky drawings * * * instead of submitting a smaller sheet that would easily contain a fair sample of their work." * * *

Commenting on this letter the Engineering News states editorially:

* * * "Mr. Bock's suggestions, are likely to be found useful, not only by the large crop of June graduates of the present year, whom he mentions in his opening paragraph, but by many engineers of experience and high standing.

"It occurs to us, in this connection, to add to those given by Mr. Bock, another useful hint that we happen to know has been found helpful by many engineers inexperienced in going about the task of seeking a position. Our suggestion is that the engineer who is seeking a position should prepare a letter setting forth in fairly complete form just what his professional experience has been, including in this, of course, a statement as to his education and personal characteristics, such as a prospective employer would desire to have. A list of references, stating in connection with each reference just what particular part of the applicant's experience or characteristics it treats of, should also accompany the letter.

"This statement should be neatly typewritten on good paper of standard letter size, and a copy can then be inclosed with any letter of application or reply to an advertisement. In this way the letter of application itself can be made brief and business like, and can emphasize any special fitness which the writer may think he possesses for filling the particular position to which the

letter relates. At the same time the employer is given all the facts concerning the applicant that he is likely to need, in a form where they are readily filed for examination." * * * *

See Eng. News Vol. 76, p. 275.

§ 59. Examples of Letters of Application for Positions.—As examples of letters of application which are fairly satisfactory, several actual letters are here given in a slightly modified form.

Example A

1312 South Street,

New York, February 8, 1914.

Mr. X. Y. Z., Consulting Engineer,
213 State St.,
Buffalo, N. Y.

Dear Sir:

I am writing to request the favor of an interview with you at your convenience with the view of securing a position in hydraulic work.

I am a graduate of ——— College, and also of the Civil Engineering Department of the University of ———.

For a year I was assistant to the Chief Engineer, Mr. ———, of the ——— Water Company, and later Civil and Hydraulic Engineer for Mr. ———, Consulting Engineer, ———. I made the preliminary surveys, gagings, etc., and in the office prepared the structural and hydraulic designs for the hydro-electric plant at ———, in addition to other miscellaneous technical work.

For the last two years I have been gaining experience in construction as Superintendent for ——— and Company, Architects, of ———. I now desire to return to more strictly engineering work, and am particularly interested in hydraulic work.

I respectfully refer you to the above named firms.

It occurs to me that if I cannot be of service to you in your own practice you may know of other engineers or firms who need assistants to whom you would kindly refer me.

Very respectfully yours,

Example B

Green Bay, Wis.

March 13, 1915.

Mr. X. Y. Z., Consulting Engineer,
Milwaukee, Wisconsin.

Dear Sir:

Your name has been given by Mr. W. A. ——— of the ——— Construction Company of ———, as being connected with the design and construction of hydro-electric work.

At the present time I am looking for an opening in the engineering department on some hydro-electric or irrigation project.

I am ——— years old and an Associate member of the American Society of Civil Engineers.

From 1905-1910 I was employed by the ——— on their irrigation project in the State of ———. While there I was Division Engineer in charge of location and construction of main canals and distributing system, location of pumping plants and small power sites, earth dams, topographical, hydrographical and concrete work.

In July 1910 I was employed by ——— of New York on their ——— irrigation project in the State of ——— as Construction Engineer on their reservoir, earth dam and concrete work, and in November of that year was appointed Chief Engineer of the project, which position I continued to hold until its completion in 1912. This work consisted of a rock fill dam and concrete diversion works, fifteen miles of main canal and ninety miles of distributing laterals, nearly two miles of steel fluming, concrete headgates and syphons, and two miles continuous wooden stave pipe syphon.

I respectfully refer you to:

Mr. A. J. ———, Consulting Engineer, ———, ———.

Mr. A. E. ———, State Engineer of ———, ———.

Mr. D. C. ———, General Manager of the ——— of ———, ———.

Mr. P. S. A. ———, formerly Chief Engineer of the ——— now at ———, ———, and

Mr. ———, Treasurer of the ——— Irrigation Company, 30 ——— Street, New York.

If you have any opening along these lines that you can offer, I shall be glad to advise you further or to arrange for an interview.

Yours very respectfully,

(Signed) ———

Example C

463 Ferrell Avenue,
Des Moines, Iowa.

Messrs. ——— and ———,
462 State Street,
Chicago, Illinois.

March 16, 1916.

Gentlemen:

I respectfully submit to you my application as engineer on your staff. My experience has been as follows:

1885-90 Machine apprentice in the shops of ——— Company, builders of steam pumps and hydraulic machinery.

1890-92 Erecting pumps and hydraulic machinery for ——— Company.

1892-94 Designing and drafting room of ——— Company.

1894-95 Machinist in shops of IXL Company, SFW Company and Z Company to expand my experience in machine work.

1895-99 University of ———, mechanical engineering course, graduating in June 1899.

1899-08 With the W. X. Water Power Company, and the Q Hydro Electric Company, building and installing hydraulic machinery in their various plants.

1908 to the present time, supervising the installation of hydro electric machinery in various plants for the C. A. Company.

I am leaving the C. A. Company at the present time on account of their reduction in the force due to cessation of hydro electric work. I would respectfully refer you to their President, Mr. H. W., and to their Chief Engineer, Mr. C. K.

Hoping that I may hear favorably from you in this matter, I remain
Yours very truly,

TECHNICAL REPORTS

§ 60. **The Importance of Good Reports.**—Few technical men have ever reached more than subordinate positions without the ability to prepare a fair technical report. This is the most common form of technical writing and, excepting contracts and specifications, the form most important to the engineer. There is no writing on which his success so largely depends as on the preparation of neat, clear, logical, concise and complete reports.

The advancement of that engineer is assured who can clearly comprehend the conditions of a problem and the factors which modify and control its solution, and who can transfer his ideas and conception of those factors and conditions and the logical conclusions to be drawn from the same, to his superior or to his client in a clear and explicit manner so that every fact and condition becomes plain, every controlling circumstance becomes apparent, and every conclusion becomes obvious. The engineer should give special attention and special study to the principles and preparation of reports on account of the undoubted influence of this work on his future.

§ 61. **The Purpose of Reports.**—A report is an oral or written statement of principles, facts or conditions made to show the necessity or lack of necessity for any usual or unusual course of action. The function of the report is to point out plainly, so that those for whom the report is prepared can understand, the facts and conditions necessary to be known in order that suitable action can be taken.

Reports may cover any part of the technical field and any general treatment of the subject is impossible to do more than impress the fact that most of the requirements for technical writing and for the writing of specifications discussed in Chapters V and XV need to be especially emphasized when applied to the preparation of written reports. Different reports will require very different methods of treatment. They are usually designed to be specific and confined between very definite lines, although the field covered may in some cases be very broad.

It is always desirable that the instructions on which a report is to be based should be in writing and should specifically define its desired

extent and limitations, otherwise the point of view from which the report is to be made or the extent of the investigations necessary for its purpose may not be understood and the report may be unsatisfactory, incomplete or involve unnecessary time and expense.

Like all other technical writing, to be of value a report must be based on a thorough knowledge of the subject, and such knowledge must be specifically detailed and complete on account of the specific character of the report. An equally important condition is clearness. The findings and conclusions must be manifest and beyond question to the minds of the reader who may or may not have technical knowledge. If the report cannot be understood by the man for whom it is prepared, it is useless or worse for it may, if misinterpreted, be misleading and add to the confusion instead of clearing up uncertainties, which is its main object.

§ 62. **Preliminary Consideration.**—Before an investigation is undertaken a thorough consideration should be given to the instructions which outline the purpose of the report, and to the various factors which must be the basis of the desired report. It is desirable to first outline the various conditions and pertinent data which would in any manner affect the project, and which should therefore be investigated or secured in order that a clear understanding may be obtained and logical conclusions reached and demonstrated. In this way the opportunities for error resulting from overlooking essential elements in the problem will be largely obviated. As has already been indicated many subjects quite foreign to the technical side of the question will frequently have an important bearing on correct conclusions, and failure to give such subjects due consideration is the cause of many unsatisfactory and erroneous reports.

There is always danger that the expert may become interested in the particular subject of his specialty and lose sight of the fact that there are other subjects of equal or perhaps greater importance to which his attention should also be directed. In contemplating some form of engineering or architectural construction, the technical man is largely interested in ways and means. His client is only interested in results. While the client may desire to know the details by which the results are to be attained, his principal interest lies in the answers to the questions: "How much will it cost?" "When can it be completed?" "Will it accomplish its purpose?" If these questions can be answered satisfactorily, he is willing to leave all technical details to his professional advisers.

§ 63. **Ethical Considerations.**—In reporting on designs, structures or projects of other engineers, captious criticisms should be avoided. A report is not the place to needlessly show the superior knowledge or ability of the writer or to attempt to win over the clients of other engineers. If results can be accomplished safely and economically by the method proposed, even though in the opinion of the reporter a better design might be possible, it is generally undesirable to advise unessential or radical changes which will result in no material betterments.

The engineer may be called to report on some single phase of a project such as its safety, or on some particular part or equipment on which he is supposed to be particularly well informed. In such cases he should avoid interference with other phases of the work on which his opinion is not requested. There may be exceptions to this statement should the examination develop the existence of radical errors which may endanger the structure or the life or property of others or should the reporter become aware of gross fraud or dishonesty. He may under such conditions owe it to the public to take such action as will prevent such danger or the accomplishment of such fraud. This is a condition which requires the greatest finesse in its treatment and should in general be handled without publicity, an appeal first being made to those who are directly interested to take such action as will prevent the serious results of the proposed construction or transaction. Such appeal may be enforced by a decision to publish the facts if they are not equitably adjusted. It is perhaps needless to say that such a stand should be taken only when the conditions are such as to warrant such radical action.

§ 64. **Investigations and Estimates.**—Proper reports must be based on a suitable investigation of the subject, and this must be made as complete as the purpose of the report will warrant. Nothing that can be determined must be assumed, and the reporter must use the greatest of care to make sure that the ideas and opinions which result from his investigation are not colored by his personal bias (see Sec. 12).

When reports are of a preliminary nature, the extent of the investigation must be limited but the essential facts and conditions should be properly determined and due allowance must be made for all uncertainties (see Sec. 244).

Reports will frequently require estimates of the cost of construction or of development and possibly of fixed charges, operating expenses and cost of maintenance as well as an estimate of probable in-

come. Such estimates require careful consideration and much forethought. They must, in a preliminary report, be based on incomplete data. Contingencies of various kinds will surely arise and must be sufficiently foreseen and provided for by conservative estimates (see Sec. 252).

A thing that is worth doing at all is worth doing well, and this principle is especially true in making reports. A cursory examination or a failure to give the matter under consideration careful and complete investigation, with resulting conclusions based on insufficient or incomplete data, will most likely be misleading and may result in overlooking serious contingencies or favorable facts and conditions. Such a report may lead either to expensive investments that will be found entirely unwarranted when a thorough examination is made or in the condemnation of a worthy project. Every report should be so thorough and complete that the accuracy of the conclusions will be assured.

§ 65. Elements of Successful Reports.—Most reports depend for their value on accuracy of observation and correct deductions. They often require great technical knowledge and skill and frequently a wide practical experience. There are usually certain very definite facts or conclusions which are the essential feature around which all other facts and deductions should be centered and to which they are subordinate. Special effort should therefore be exercised to bring out and accentuate these important ideas and to facilitate the appreciation of their bearing and importance. Clear, explicit and exact statements are of special importance. Proper arrangement will not only save much time to the reader but will emphasize the importance of the main ideas and the relation of the subordinate factors. When desirable to recite all the facts and conditions in great detail, the essential matters pertinent to the immediate purpose of the report should be emphasized so that this importance can be distinguished and the logical conclusions made manifest.

The technical report is often the pioneer report on the subject; later the legal and other aspects must be examined and passed upon by specialists in each line, but in its preliminary stages, the engineer must frequently look into each phase, and if his report is to bear expert scrutiny it must be based on a broad understanding of many things.

In the preparation of reports on technical projects, the engineer needs more than technical training. In such projects, questions of law, business, transportation, market conditions, manufacturing, agricul-

ture, politics, economics, finance and many other factors may be of even greater importance than the technical factors involved.

Every engineer who is called upon to report the feasibility of a project must duly consider not only the technical problems involved but also all other aspects, for the practical and economical success depends on its feasibility from every point of view. The project is not a success simply because it is well and economically designed and properly constructed, but it must also be successful from commercial and financial standpoints.

Numerous projects in water power, irrigation, drainage, manufacturing, etc., have resulted in failures because some necessary phase has been overlooked and remained unconsidered.

A report may be complete, it may be technically correct, it may recite all the facts and discuss all conditions and details, and yet it may be a practical failure if it does not recognize the human side of the problem and differentiate the essential details in such a manner that the every day business man, the director, the banker or the citizen may appreciate the essential facts and the logical solution of the problem.

A scientific statement of fact or principle may be satisfactory if the report is made to a technical superior but it may be meaningless if made to a layman. It is the business of the reporter to translate the scientific statement into such language that its practical significance can be fully understood by the reader with the degree of knowledge and understanding that he possesses. It is seldom necessary to demonstrate the principle or prove the fact; these will be assumed as correct on the basis of the technical knowledge, experience and reputation of the reporter, but their bearing on the issue involved must be so stated as to be readily comprehended.

It is often essential that the report should include all of the data on which discussions are based. These data and their bearings on the project discussed and the reasons for the opinion expressed should be clearly set forth. In a well drawn report the engineer can usually so illustrate and describe the conditions by which a project is modified and controlled, that any good business man will understand the basis on which the opinion rests, and the degree of probability of any departure from the expected results. While a similar comprehension by nontechnical readers is not to be expected in regard to the technical details, an understanding of the general considerations on which the feasibility of the project depends can be secured. If a report can not be so drawn it is usually due either to insufficient data or to the fact that the en-

gineer himself does not fully understand and appreciate the logic of the situation.

For simplifying scientific facts, principles and data, graphical diagrams are of great importance. They give a significance to figures and data which is not otherwise apparent.

The report should usually be accompanied by such maps, drawings and sketches as may be necessary with the data furnished, to clearly illustrate the conditions and show conclusively that the conditions are such as the report sets forth.

In most cases facts and data should be given in such a manner that the report may be checked up by others who are informed on the subject and the conclusions given in the report should be such as will be clearly demonstrated by the facts in the case and the available data. Reports should never consist of general conclusions or mere opinions but should be the logical outcome of facts, conditions and data.

In general it is essential that the report itself should be clear, concise and definite in its statements and recommendations. Any elaborate discussions of voluminous data should usually be contained in the appendix to which the main report should refer for confirmation of its facts and recommendations. Even under such conditions it is well to summarize the conclusions and such a summary may be introduced in the closure of the report or may sometimes be included to advantage in a short letter of transmittal, which may be used as an introduction to the more extended treatment in the report.

LITERATURE

Effective Business Letters. A. H. Gardner. The Ronald Press Co.

Putnam's Correspondence Handbook. Eleanore Banks. G. P. Putnam's Sons.

The Applicant's Difficulties, by R. Fleming. Eng. News, Vol. 75, p. 1085.

Water Power Engineering. Chapter 24, The Consideration of Water Power Projects, by Daniel W. Mead, McGraw Hill Book Co.

The Preparation of Engineering Reports. Notes on the requirements of a report. Edward B. Stephenson. Eng. News, Vol. 70, p. 1219.

CHAPTER VII

ORIGIN, NATURE AND DEVELOPMENT OF LAW

§ 66. **Origin of the Present Civilization.**—The present state of mental and material development of the nations of the earth is the result of influences many of which may be traced back to the dawn of history. Men and nations, and their laws, customs and relations are not alone what modern civilization has produced but have been created by influences which have been acting from the most remote times. The heritage of today, the social, political and religious institutions are due to many people and to other nations, many of which have long ceased to exist but which nevertheless have left an indelible impression on present social, political, mental and moral development, and on the thoughts, acts and daily lives of present generations.

Those who read Draper's *Intellectual Development of Europe*, or White's *Warfare of Science and Theology*, will find these influences pointed out as they have affected certain lines of modern thought, and will realize that advancement in all lines is the result of many influences which have modified old ideas and old relations and have been largely instrumental in creating the present conditions which now obtain in every country.

§ 67. **Law an Evolution.**—It will be found that the laws of to-day which guard our rights and privileges and limit and control our actions, were not created entirely new for the particular needs of the present time, but have descended from the past, changed and modified as necessities have demanded but still having their root, their origin and foundation in the past.

The term "law" is familiar in numerous applications, having always, however, a somewhat similar signification. Technical students are perhaps most familiar with "natural laws" on which the sciences are based. A knowledge of such laws is a most important element in technical education.

Engineers and architects study the laws of mechanics, the laws of electricity, of chemistry, of physics, and of the various other subdivisions of science. The lives of most engineers are largely spent in investigating such laws and in utilizing them for the accomplishment of desired results. Such laws have been slowly derived but not created by man, they are fixed and unalterable and are never broken.

Plants and the lower animals follow the natural laws of growth and development and the instinct which is also their established natural law. Mankind is also influenced and controlled more largely by natural laws than many are apt to realize. Heredity, environment, education, all affect every action and every thought and opinion.

That which is termed moral law may be defined as the general moral tone or feeling of a community to right and wrong action. The punishment for neglecting or disregarding moral law is public disapprobation, contempt or ostracism. It changes to some extent with every decade, and differs with different time and different nations. Divine law is believed to have been received from Deity and forms the basis of all religion, and probably has had greater influence on human actions than any other except natural laws.

The divisions of laws which may be termed human laws and which are intended to influence or govern human actions, are somewhat different in character. Most of these laws are not unalterable nor unchanging; nor are they always obeyed. These laws man has seen fit to establish for his own guidance and protection to enable him to live in safety and at peace in the enjoyment of such right and privileges as his state of civilization has made possible.

§ 68. **Development of Human Laws.**—Primitive man probably lived entirely under natural laws. He obtained those things which his strength and agility would permit; with him, as with the lower animals "might made right" and his existence was largely a continuous struggle. With his mental development he began to realize that his individual instincts and interests were hardly sufficient for his guidance. He began to see that his neighbors had rights equal to and often in conflict with his own, and that unless he would live in constant warfare, it was absolutely essential that the rights of all be so regulated as not to interfere, or so as to interfere as little as possible, with the equal rights of others. In order to protect himself in the enjoyment of his own property and rights, he was obliged to make laws for the regulation of his own conduct. Such laws were at first largely regulated by custom or by the opinion of the head of the clan or tribe. Whatever was customary or usual was considered right and became the law. These laws have grown, developed and have been altered and expanded as the races of mankind have grown and developed and experienced new demands for the protection or extension of their social, political and business relations, and they constitute today the vast legal fabric which controls and modifies every line of civilized human activity.

There may also be mentioned international law which consists of the rules, precedents and customs by which independent nations govern their dealings with each other.

§ 69. **Municipal Law.**—The subject which is particularly important to here discuss is municipal law which consists of those rules by which the civil rights and conduct of the citizens and residents of a nation with each other are regulated.

Municipal law may be subdivided into written law and unwritten law. The former consists of those positive enactments of congress, of the state legislature, or of city councils, which are passed to meet some particular need or to effect some particular result. They sometimes simply affirm known principles of law and sometimes are passed to modify or nullify some particular established principle. For example, by ancient unwritten law a married woman could not hold personal property or make contracts; now by enactment in most states her disability has been removed and she can act as fully in legal matters as an unmarried woman.

Unwritten law is the most extensive and the most important body of law. It includes the Civil Law and the Common Law.

§ 70. **Unwritten Law.**—Civil Law is the basis of the Continental European Jurisprudence System and largely affects English and American law. It consists of the laws of the Roman people and the edicts of kings and of the senate, and of legal decisions and learned opinions. This was codified by order of Emperor Justinian in the Sixth Century.

The Justinian code was modified and reformed by Napoleon, is used in France today and is the basis of the laws of Italy, Spain, Germany and Holland. The civil law was also brought over to England by William the Conqueror in 1066 and has had its effect on the laws of England. It has influenced the local laws of certain states through the early French and Spanish settlement.

The common law of England was brought to this country by the first English settlers. It consists largely of customs and usages. Such customs and usages when they became well established were regarded as established laws and were upheld by the courts at a later date when courts were established.

Courts were obliged to discriminate between well established customs and more recent customs. If the custom existed "from a time whereof the memory of man remembereth not to the contrary" they were upheld by the court. These customs were binding only in the

community where they were observed; they were frequently very limited in extent.

Customary usage still has the effect of law in many matters at the present day, except where direct legislation has intervened. Thus a cubic yard of crushed rock may consist of a customary weight of stone instead of measured quantity. A cord of wood sawed to stove length may be a customary quantity of less than an actual cord. A perch of stone may be a customary quantity less than the actual perch, and such customary methods of measuring materials will hold in law unless such measurements have been otherwise fixed by direct legislation or by contract.

In early times the people of England were under many kings. All were united by Egbert (Kent—828) after many years of warfare. Their customs which differed widely in the various kingdoms, were in almost hopeless conflict. Alfred the Great (who died in 900) harmonized these laws, digested and analyzed them, and provided a great book for convenient reference. This digest of the common laws of England is the fountain head of the great body of laws, and of the law that now exists in both England and America. From these the common law of England and America has grown and developed, principally from the court decisions of disputed cases.

§ 71. Development of Common Law by Judicial Decisions.—Although legislative action is the most conspicuous source of modern laws, it is not the source of most of the laws which regulate the personal business relations of men.*

“Legislative activity has been in the main directed to the organization, to the administration of government; in legislations of a public character such as provisions for the collection of revenues, for the maintenance and regulation of public highways, for the licensing of special trades and other administrative acts. In the great field of private law regulating the relations of individuals with each other, a field from which the vast majority of every day subjects of legislation arise, our legal system is still essentially the product of judicial decisions. Legislative invasion of this field is, principally, only for the purpose of amendment of detail.”

These decisions form a precedent which serves to settle other similar cases. Courts are not at liberty to ignore decisions of previous courts for these decisions are part of the common law and “no man is

*Law, Its Origin, Nature and Development, by L. A. Huston. Modern American Law, Vol. 1, Sec. 17.

wiser than the law." The countless decisions of courts in Europe and America, the records of which fill thousands of volumes, are to an extent binding upon the courts which decide similar cases today. Each new decision becomes part of the common law.

Theoretically the law never changes. Practically, it is constantly being revised and modified to meet new conditions as civilization and its accompanying business transactions demand. While past decisions are binding in a sense on courts of the same jurisdiction, still, as new situations arise, precedents as established by previous decisions can be and are more or less extended, modified and moulded by new decisions into conformity with the necessities that arise. It must not be understood that these decisions of the courts of common law are absolute, or that they cannot be departed from under any conditions or circumstances for, if judicial decisions have been established in a particular way for a number of years and it is found that on account of public policy an absolute change is necessary, such changes are made by the courts of common law themselves. The courts seldom, however, flatly disregard precedent, but usually hold that the remedy in such cases lies with the legislative body. When the common law is inconsistent with the needs of the community and the evil becomes a crying one, the legislature will usually step in and make such alterations as conditions demand.

It should also be noted that these decisions are binding only in a limited sense. They are binding on courts of common jurisdiction,—that is in the jurisdiction under which the decisions have been rendered. Wisconsin decisions are binding on Wisconsin courts; New York decisions on New York courts; and English decisions are binding on English courts. Where a case is to be decided on lines for which there is no precedent in the jurisdiction of the court where the case is heard, the decisions of the common law courts in other jurisdictions will have an important influence on the decision of the court.

§ 72. **Courts of Common Law.**—The courts of common law have various names in various states. "Justice Courts" are established to try petty cases involving claims not exceeding \$200. From these courts appeals may be made to the next higher courts. The term "Circuit Court" is perhaps the most common name applied to courts of common law. Provisions are also made whereby the verdict of such courts on first resort may be reviewed or carried by appeal to a second court, sometimes termed a court of appeal, and sometimes to a third court of final jurisdiction usually known as the Supreme Court of the States.

In such courts the decision is usually final, unless some constitutional questions are involved which will permit of its being taken to the Supreme Court of the U. S., the decision of which will in such case prevail. Cases between states and between citizens of different states if they involve amounts of \$2,000 or more are taken into the United States Circuit Court from which they may pass to the United States Court of Appeals and thence to the United States Supreme Court.

The objects of the common law are (1) to protect the rights of individuals, and (2) to redress the wrongs to which they may have been subjected. The laws which protect the rights which men possess and define the infringement of those rights are called substantive laws. The law by which criminals are punished and wrongs redressed are called remedial laws.

§ 73. **Subdivisions of the Common Law.**—Substantive laws define rights and wrongs. Rights include legal rights which the law will recognize and protect. Wrongs include such wrongs as are recognized by the law and for which the law will offer a redress.

Blackstone subdivides rights into rights of persons and rights of things. The first relates to the person of men as distinguished from their property and includes the right which every man has to enjoy personal security, personal liberty, and personal property, also the liabilities and rights arising from mutual relations such as master and servant, principal and agent, guardian and ward, husband and wife, parent and child.

The right of things includes laws which deal with the acquisition and ownership of real and personal property, including the accompanying right and liabilities.

Wrongs may be subdivided into public wrongs and private wrongs. Public wrongs are those committed against the whole community and which are termed crimes and misdemeanors. Private wrongs are not such as are dangerous to the community at large, but are those which inflict loss on the individual and are known as torts.

The penalty for public wrongs may be fines or imprisonment, while those for private wrongs include restitution for the losses suffered.

Remedial law controls the organization of courts and the methods by which claims can be enforced therein. In both this country and in England there are two great systems of courts, the courts of Common Law and the Courts of Equity.

The court of common law is the court to which reference has previously been made. These were the earliest courts in existence in Eng-

land and were transplanted to this country by the first English settlers. Such courts are governed entirely by common law practices and are strictly bound by precedent.

§ 74. **Courts of Equity.**—A second great system of courts has, however, been developed in both America and England known as courts of equity. These owe their existence very largely to the limitations of the common law courts. The court of common law can compensate the individual for the infringement of his legal rights, but it cannot prevent such infringement. These courts can punish the individual for not carrying out the terms of his contract but they cannot enforce the fulfillment of the contract. They are so bound by precedent that while they can compensate individuals for injuries done him they cannot prevent those injuries, even if they may be known in advance and be irreparable in nature.

To provide for such contingencies, the system of equity courts has been developed. A court of equity offers what is known as "extraordinary remedies," that is to say, it offers remedies not recognized by the common law. It also differs in that it is not bound by iron clad rules of precedent, but seeks to administer absolute justice. In some states the courts of common law also administer both common law and equity; in other states the courts are separate and distinct.

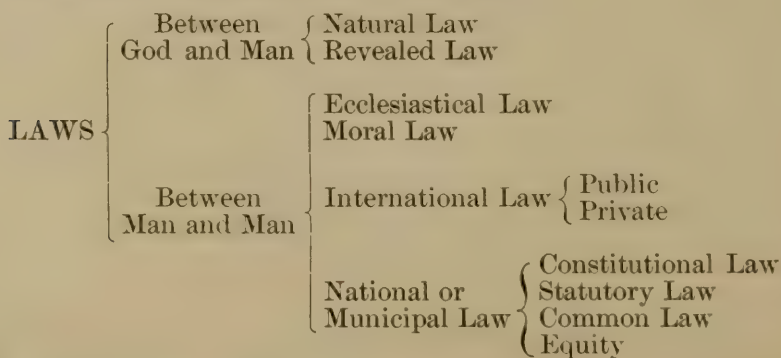
§ 75. **Fundamental Laws.**—It should be understood that besides the civil and the common law (the unwritten law of the land) previously referred to, there is also the written law, the basis of which is that fundamental law of the state or nation: viz., the national and state constitutions. This fundamental law is from the people themselves and is adopted by their direct franchise and can be changed only with their consent. Congress or the legislature cannot alter these constitutions, nor can they pass valid laws antagonistic therewith. In the United States the fundamental basis of law so far as it applies is the Constitution of the United States. With this all state constitutions must agree and no law is valid which is contrary to either the United States constitution or the constitution of the state in which it is passed.

§ 76. **Development of Special Laws.**—Under all of these conditions, which may appear at first glance as greatly complicated, the great body of the law affecting various features of civilization has been developed. Probably the first branch of law that attained importance was that in relation to land. Other laws developed to govern and regulate men's action toward each other in various new relations which developed with civilization. The acquisition and ownership of movable

property was followed by the laws relating to personal property. With the development of trade it was found necessary for mankind to form agreements with each other for specific purposes which led to the development of the laws of contracts. The development of commerce became so extensive that the law of agencies became necessary. For the purpose of facilitating commerce, laws relating to transfer of negotiable paper were developed. At the present time the great increase in corporate business has led to great development in the laws relating to corporations. Other specialties in which engineers are specially interested are the laws of franchises, the laws governing water and water rights, the laws of eminent dominion, and the patent laws. These laws are in fact so numerous that a mere catalog of their subjects would require much more time and space than are available. It is hoped however that some idea has been given of the gradual growth and development of laws, and that the reader has been impressed with the fact that as they now exist they have come down to us from most remote times and have been modified as circumstances seemed to require. While these laws are far from perfect, they represent the customs and best ideas of the past and are slowly modified to meet the new conditions that arise. A study of the laws that will affect the special work of the individual in practice will be of great service and will aid him in knowing his own rights and privileges, the rights and privileges which must be accorded to others, and when he should seek adequate legal advice.

OUTLINE OF LAWS AND LEGAL RELATIONS

§ 77. General Classification of Law.



§ 78. Definitions of Law.

- I. *General*. "A rule of action prescribed by authority." Century Dictionary. "A rule of action established by recognized authority to enforce justice and direct duty." Stand-

ard Dictionary. "A governing rule of action." Benjamin. "A rule of action, that which is set, fixed, prescribed or laid down beforehand." Spencer.

II. *Laws between God and Man.*

1. *Natural laws.* Statements of the invariable sequence of natural phenomena. Law of gravity. Boyle's law, etc.
2. *Divine or revealed law.* Those rules of action supposed to be laid upon man by Diety. Mosaic law.

III. *Laws between Man and Man.*

1. *General.* Rules for the control of human action; these were "created by man for his own protection, except insofar as religious writings are considered to be laws laid down by the Diety."—White.
2. *Ecclesiastical law.* Laws of the church or other religious associations.
3. *Moral law.* Those rules of conduct approved by the community.
4. *International law.* Those precedents or customs observed by independent nations.
 - (a) Covering mutual rights and duties of nations.
 - (b) Covering rights and duties of citizens when in foreign states.
5. *Municipal law.* Those rules of civil rights and conduct which regulate the action of the inhabitants of a nation or state with each other.

IV. *Further definition.*

1. *Positive law.* Those rules of conduct and of interrelation prescribed and enforceable by public authority; the "law" of the courts. Positive laws in general reflect the popular conviction of that which is reasonably just, equitable and proper in the conduct and relations of man to man under the average circumstances of the state in which they prevail.
2. *Substantive law.* Defines individual rights and that which constitutes infringement on those rights.
3. *Remedial law.* Relates to the organization of courts and the manner in which rights may be enforced therein.

§ 79. Sources of Municipal Law.

I. *Written Law.*

1. Constitution of the nation.

2. Constitution of the state.
3. Statutes of nation.
4. Statutes of state.
5. Ordinances of minor political subdivisions.
6. *Contracts*. When not opposed to public policy or to the law of state or nation, two or more individuals may, by mutual consent, prescribe for themselves rules of action under certain conditions which the public authorities will enforce, viz: contracts.

II. *Unwritten Law*.

1. *Civil law*.

- A. Origin. Justinian Code as codified from ancient Roman laws.
- B. Basis of all Continental European system of jurisprudence.
- C. Largely influenced English and American law through William the Conqueror who conquered England in 1066.
- D. Louisiana largely influenced by French laws; territory acquired from Spain largely influenced by Spanish system of law, both of which are civil laws.

2. *Common Law*.

A. Origin.

- (a) All the laws of England, either statutory or common which were in force at the time of the Declaration of Independence, and recognized by our courts, and which have not since been repealed.
- (b) All those universal or local usages which the courts recognize as having force of law.

B. Growth—by judicial decision; by established local usages.

C. How modified—by statutes; by judicial decisions, and to some extent by contract.

D. Parol contracts.

E. Quasi contracts.

§ 80. Definitions Concerning Municipal Laws.

I. *Subject Matter*.

1. Political law: relating to administration of state or nation.
2. Criminal law: relating to offenses directly prosecuted and punished by the state or nation.

3. Civil law: relating to legal rights and duties of individuals and legal remedies for their violation.

II. *Object.*

1. *Primary rights.* All those rights allowed by law or arising from contracts.

A legal right is "a power, capacity or liberty given or allowed by law to a person in relation to some person, thing, act, or forbearance."—Benjamin.

A. Rights of person. Deals with rights of the person as against any other individual, viz: those rights which attach to persons as compared with those that affect property, both as to individuals and corporations.

(a) Rights and duties which attach to the individual and to his acquiring, using and disposing of property, viz: rights of personal liberty and security; rights to property.

(b) Rights and duties of individuals when forming social relations, viz: rights of the individuals as husband and wife—parent and child—master and servant—principal and agent—landlord and tenant.

(c) Rights and duties of individuals to associate as partners, corporations, etc., to acquire, use and dispose of property, viz: rights of partnerships and of corporations.

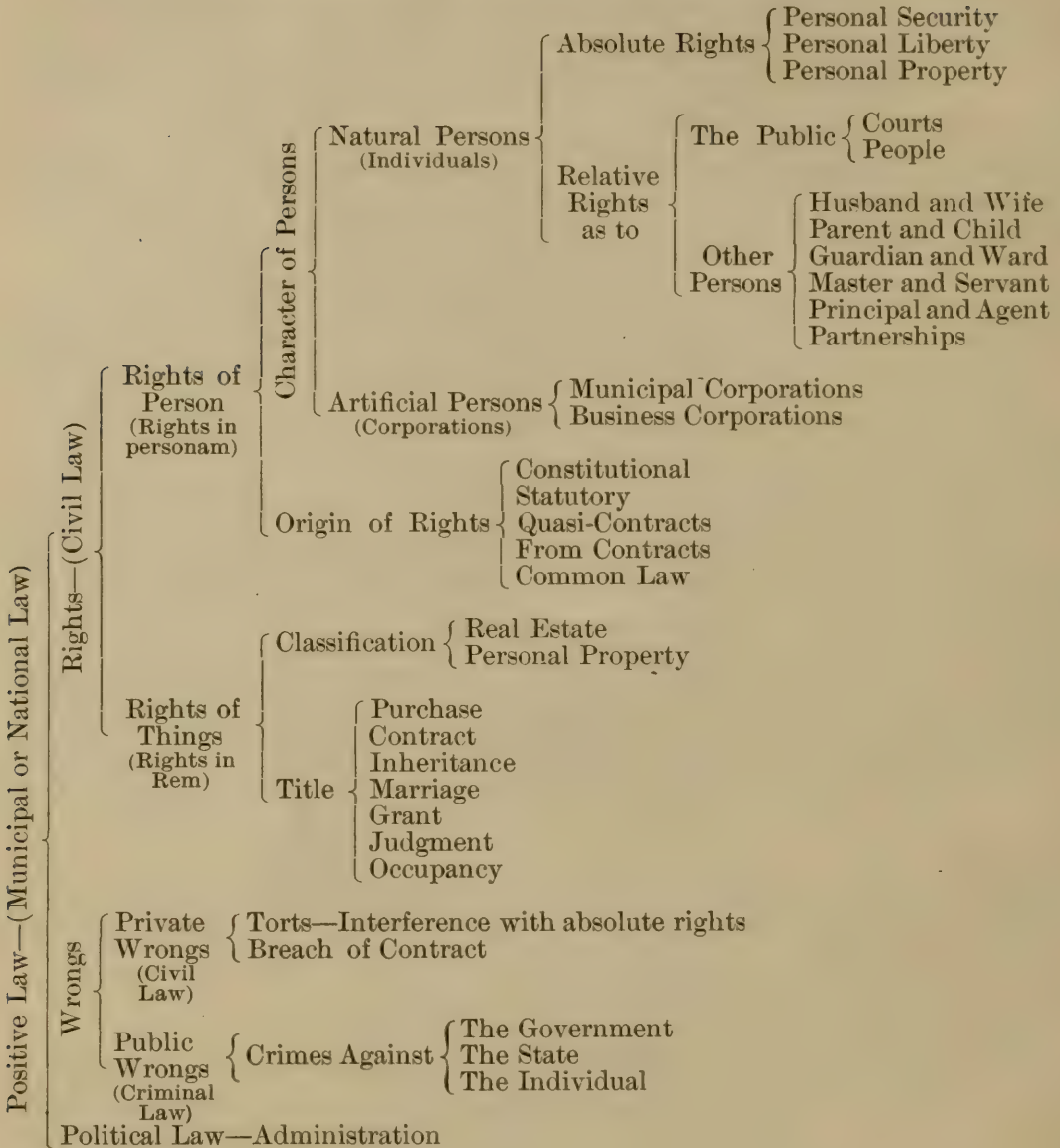
B. Rights of things. Deals with the rights of the person as against all the world such as the acquisition and ownership of personal property and real estate, with the corresponding rights and liabilities.

2. *Wrongs.*

A. Private wrongs,—torts—are those wrongs not injurious to the community in themselves, i. e. injury of one individual by another through carelessness or neglect of his legal obligations.

B. Public wrongs,—are those committed against the state, i. e. against the whole community, viz: disturbing the peace, disorderly conduct, misdemeanors and crimes.

§ 81. Classification and Relation of Positive Law.



§ 82. Enforcement of Law.

I. *In General.*

1. *Natural law.* Invariable laws of nature.

Natural laws are always enforced. The engineer may so modify the conditions that the occurrence of natural phenomena will not be detrimental to human interests or so that their occurrence will be more favorable to human interests, as the case may be.

2. *Divine law.* Hope of future reward and fear of eternal punishment.

3. *Eccelesiastical law*. Church approval vs. excommunication or church censure.
4. *Moral law*. Self-approval vs. self-censure, and approval vs. censure of society or community.
5. *International law*. Approval vs. disapproval of nations—possibilities of war.
6. *Municipal law*. Popular approval or disapproval and penalties prescribed by nation, state or municipal statutes.

II. *Remedial laws*,—may be enforced by

1. *Courts of Common Law*. Governed by common law rules and strictly bound by precedent. Functions, punishment and compensation for acts after they occur.
2. *Courts of Equity*. Extraordinary remedies not recognized by common law; injunction against unlawful action,—enforce specific performance.

III. *Enforcement of Remedial Laws*. Jurisdiction of courts, of common law. Every person lives under three forms of government,—national, state, and local. In most states the courts for the enforcement of remedial laws are as follows:

1. *Justice courts*,—which are limited to cases involving not more than \$200.
2. *Circuit Court*. Cases that arise under laws of the state; also those that arise under laws of the United States where amount involved is less than \$2,000.
3. *Supreme Court of State*. Review of circuit court cases; also court of original jurisdiction in cases involving constitutional questions.
4. *U. S. Circuit Court*. Cases under United States statutes; also cases between citizens of different states, involving property rights of more than \$2,000.
5. *U. S. Court of Appeal*. Review of circuit court decisions.
6. *U. S. Supreme Court*. Review of decisions of court of appeal and of supreme courts of states. Court of original jurisdiction in questions involving United States constitutional questions.

LITERATURE

Engineering and Architectural Jurisprudence, by J. C. Wait. Wiley and Sons, New York.

Laws of Operations Preliminary to Construction in Engineering and Architecture, by J. C. Wait. Wiley and Sons, New York.

Manual of Commercial Law, by E. W. Spencer. The Bobbs-Merrill Co., Indianapolis, Indiana.

Laws of Business, by Theophilus Parsons. The S. S. Scranton Co., Hartford, Conn.

Business Law, by T. R. White. Silver, Burdett & Co., New York.

Dictionary of Law, by W. C. Anderson. T. H. Flood & Co., Chicago.

Cyclopedic Law Dictionary, Shumaker and Longsdorf. Callaghan & Co.

Burgess' Commercial Law, by K. F. Burgess and J. A. Lyons. Lyons & Carnahan, Chicago.

CHAPTER VIII

SOME LEGAL RELATIONS OF TECHNICAL MEN LEGAL RIGHTS AND RESPONSIBILITIES

§ 83. **Employment in General.**¹—The employment of the technical man in trade, business or professional work is a contract and must contain all the essential features of a contract. Such contracts are seldom written and are subject to the verbal agreements made when the employment is consummated. Acceptance of employment is a warranty that the employee is competent to do the work accepted in a reasonably satisfactory manner and that he will do it faithfully and in accordance with lawful direction. Gross moral misconduct is a warning to employers of which they are privileged to take advantage.

If the employment is for an indefinite period or is to continue so long as either or both parties are satisfied, it may be terminated without notice and without expressed reason. If a certain notice of termination is required, such notice must be given by either party who desires its termination, except when the employee is discharged for cause. Employment for a definite period “unless sooner terminated” cannot be terminated prior to the end of the period without proper cause.

If the employment is for a certain definite period and the period if allowed to elapse without notice, the law assumes a renewal of the contract for a like period.

Contracts for employment, not in writing, for services which cannot be rendered within a year are void,² but if the services are actually rendered, payment for such services can be enforced, not on the contract but on *quantum valebat*.

When a person is employed at a fixed rate (except the rate be for hours of service), and additional duties are imposed, he cannot secure extra compensation without an express agreement to that effect.³

To assure remuneration for services rendered it is important that the contract for employment be made with those legally empowered to make such contracts.

¹ Engineering and Architectural Jurisprudence, by J. C. Wait, Chap. 28.

² See Statutes of Fraud, Sec. 107.

³ Waite, Sec. 810.

The officers of a private corporation must be duly authorized by the Board of Directors to employ service or payment for such service may be avoided. The employment of an official of a private corporation to do certain things which cannot be done without assistants, clothes him with authority to employ such assistants.

The officials of a municipality cannot legally contract for services for the payment for which no appropriations are available.

Occasionally engineers are employed in good faith on consulting work by municipal authorities, but no adequate arrangements are made for paying for their services. In some cases a certain appropriation has been made but this had been exceeded by the expenditures. In such cases an injunction will lie, preventing any payment in excess of the amount provided. While such an injunction is unusual, it is always possible, and proper provision for sufficient funds should be made before the services are rendered.

§ 84. **Discharge.**⁴—Employment may be terminated by an employer before the contract term of service has expired by reason of any of the following causes :

1. Willful disobedience to lawful orders.
2. Gross moral misconduct.
3. Habitual negligence.
4. Incompetency or incapacity.

§ 85. **Professional Employment.**—The relations of the professional man to his client are confidential or fiduciary. To prevent undue advantage from the unlimited confidence which such relations involve, the law requires the utmost of good faith in all transactions between the parties. In accepting service in a professional capacity therefore the individual also accepts certain responsibilities without a special agreement.

The responsibilities legally implied in such cases are summarized by Wait as follows:⁵

1. That he has the requisite skill and knowledge.
2. That he will use reasonable care and diligence in the exercise of his skill and in the application of his knowledge.
3. That he will use his best judgment ; and
4. That he will be honest.

If the professional man neglects or fails to exercise any one of these requirements and injuries or damages result from such neglect or failure, he is liable under the law for such injury or damages.

⁴ Waite, Secs. 802-806.

⁵ Wait, Sec. 831.

The law holds every man who solicits employment in any vocation or profession, responsible for the skill, ability and learning necessary for the reasonable performance of his work. His liability is determined by his contract for employment, which may be written, verbal or implied, and is the same whether his services are rendered gratuitously or for a reward.

If the client is aware of the professional incapacity of his employee, where employment is given, no implied liability is entailed but only such liability as will result from actual warrantee.

The employment of a professional man does not imply perfection in his work, or the safety or durability of his designs or construction, unless it is proved that unsatisfactory results are due to lack of ordinary skill, care or attention. The acceptance of employment by a professional man does not imply or warrant satisfactory results, but failure due to his direct fault or neglect will render him liable for damage. The duty of the professional man is a duty of reasonable care and diligence in the performance of his work. "There is no implied promise that miscalculations may not occur. An error of judgment is not necessarily evidence of a want of skill or care, and miscalculations are incident to all the business of life."⁶ He is responsible for the consequences of miscalculations and errors only when it is shown that such miscalculations and such errors could have occurred through lack of reasonable knowledge, skill and diligence; and such knowledge, skill and diligence must be such as would be possessed and exercised by a reasonably prudent man in the same profession. Thus ⁷ an engineer or architect who designs a foundation improperly because he has negligently failed to advise himself as to the character of the soil,⁸ or who carelessly provides boiler flues in excess of the capacity of the chimney ⁹ is liable for the resulting loss.

The liability of the professional man is determined by the nature of his contract for employment. This is seldom in formal written form but is usually the result of correspondence or verbal agreement, and often is not definable with any degree of certainty. If, however, he accepts employment with an actual or an implied agreement as to certain definite results, those results must be reasonably approximated

⁶ *Coombs v. Bede*, 89 Maine, 187.

⁷ *The Legal Liability of Architects and Designers*, by R. N. Miller. *The Rose Technic.*, Vol 25, p. 117.

⁸ *Louisiana Molasses Co. v. Le Sassier*, 52 La. Am. 2070.

⁹ *Hubert et al vs. Artken*, 15 Daly (N. Y.) 237, 2 N. Y. Sup. 711.

or he cannot recover for his labor and may be held liable for any damages that occur. If for example an architect is employed to design a building to cost a specified sum, and the plans when finished cannot be carried out without an expense which greatly exceeds that sum, the architect cannot collect for his services; and if the work of construction is undertaken before the fact of excess cost is determined and the specified cost is greatly exceeded, the architect may be liable for such damages to his client.¹⁰ A small difference is immaterial, but the specified sum must be reasonably approximate; but if the client after finding out that the cost will be increased, decides to use the plans, he must pay for them.

§ 86. **The Engineer as an Agent.**—Where an engineer or architect undertakes to supervise the construction of work, he becomes an agent of his client with the authority and subject to the liability of agents.

The authority of an agent¹¹ unless otherwise known or limited, consists of:

1. Those powers directly conferred.
2. Incidental powers reasonably necessary to carry into effect the powers directly conferred.
3. Powers which custom and usage have added to the powers directly conferred.
4. Such other powers as the principal has by act, neglect, omission or acquiescence caused or permitted those dealing with the agent to reasonably believe he has conferred.
5. Powers exercised by the agent and subsequently conferred by the principal.

The duties of an agent are laid down by Spencer¹² as follows:

1. To act with scrupulous good faith toward the principal.
2. To account fully and properly for all proceeds, profits and disbursements of the agency.
3. To exercise due care, diligence and prudence in the management of the principal's affairs.
4. To obey all lawful instructions.
5. To notify the principal of all essential matters affecting the agency.
6. To act in person except where authority to act through another is expressed or implied.

¹⁰ *Edward Barron Estate Co. v. Woodruff Co.* 163 Cal. 561, 126 Pac. 351.

¹¹ *Contracts in Engineering.* J. I. Tucker, Sec. 146.

¹² See *Manual of Commercial Law.* E. W. Spencer, Sec. 578.

The extent of the powers of the engineer or architect should always be defined in the contract. When this is not done, such authority will be determined by the character of the construction and the objects intended to be accomplished. Authority to adopt reasonable and proper means to carry the contract into effect will be inferred.

The engineer has no other authority in the supervision of work than that which can reasonably be inferred from the nature of the work, or that which is specifically provided in the contract. Inferred authority is open to dispute so that it is always desirable that the details of the authority to be delegated to the engineer should be specifically provided in the contract.

In the absence of special provision therefore, the engineer or architect cannot delegate his authority to another. Such positions are positions of special trust and confidence in the professional knowledge, skill and judgment of the employee, the client has the right to select his own agent and might not be satisfied with the selection of another.

The engineer or architect is liable for the acts of his assistants when he employs such assistants on his own account to assist him in his undertaking, but not when such assistants are employed by his client even though he select them on behalf of his client and they are subject to his own direction and control.

The engineer or architect is presumed to know the extent of his own power and if he exceeds his authority and work is done under his direction for which he has no authority, he makes himself personally liable.

§ 87. **The Engineer as Arbiter.**—It is common in construction contracts to confer upon the engineer or architect arbitrary powers to reject or condemn work or material which in his judgment is faulty, and in some cases to require certain expenditures for inspection, protection or safety of the work, if in his judgment they are necessary but which may be burdensome and unfair if not administered in an impartial and judicial spirit. These powers have been sustained by the court when exercised in apparent good faith. Against this arbitrary power the contractor has no redress unless corruption can be shown.

In a Canadian case of this kind the court said: "I have always thought the position of an arbitrator a most absurd one. He has powers given him that are given to no other being in the world, and it results in hard feeling and litigation; but the parties if they choose to enter into such a contract must abide by it, having put him in position of sole arbitrator they have to show, if they want to hold him liable, not

that he has exercised a very poor judgment but that he is unskilled, that he has been dishonest and fraudulent.¹³

As lack of good faith or corruption is often hard to demonstrate to the satisfaction of a court or jury, the contractor may be unfairly used and put to much unnecessary expense through the ignorance, injustice or even the malicious decision of the engineer.

It is evident therefore that, when by the terms of a contract an engineer or architect is clothed with discretionary or quasi-judicial power and exercises that power in good faith, he cannot be held responsible for his acts or findings. Such conditions obtain when he acts as arbitrator or referee in the determination of disputed questions or of matters of fact which appertain to the completion of work or the basis of payment for the same.

The same principles hold in the exercise of discretionary power by a public officer; in general such officers are not liable to private individuals for injuries resulting from their act or neglect or for the acts or neglect of their subordinates. The public official being elected or appointed can not be held on an implied agreement to exercise the requisite skill, diligence and judgment for his work.

§ 88. Ownership of Plans, Designs and Inventions.—Unless otherwise specifically agreed, the plans for a structure will belong to the owner when he has paid the engineer or architect a reasonable price for his services, at least during the time and for the purpose of construction. Whether or not the designer can require a return of the plans after their use, even when such is shown to be the universal local custom, has not been clearly settled.

The unauthorized use of such plans by copying or building from them is held illegal, unless they are published to the world, in which case, unless copyrighted, they have become public property.

The plans, designs and inventions of an employee are the property of the employer only if such ownership is agreed or reasonably implied.

Where a professional designer is employed for the purpose of design he has no rights in the design produced during his employment, but the rights of discovery of a new method of construction or of a new process or material, would remain in the employee, although the employer might retain a license to use them if the discovery was in the direct line of effort for which the designer was employed. The results

¹³ Bagley v. Dickson, 13 Ont. App. 484; also Wait, Sec. 848.

of the work of the designer outside of office hours are however his personal property. In general, the same principles apply to inventions.

THE ENGINEER IN LEGAL PROCEEDINGS

§ 89. **Necessity of Expert Service.**—In litigation involving technical matters it is commonly necessary for the parties involved to call in engineers who are specially informed on the matter in question. This is made necessary by the fact that the attorneys employed, while possibly learned in the law affecting the case at issue, cannot be informed on the many and diverse technical matters which they are called upon to present to the courts. It is highly desirable that the attorneys employed on any technical case should have had previous experience on similar cases, as such experience will greatly facilitate the preparation of the case and assure its more adequate presentation.

In any event technical litigation will ordinarily require expert service for the purpose of :

First: Consultation in regard to the technical details involved.

Second: Assistance in the preparation of the case.

Third: Assistance in the examination of technical witnesses by the attorney.

Fourth: As expert witness.

§ 90. **Consultation.**—In most cases where litigation arises concerning technical projects or affairs, there are certain questions involved which are more or less doubtful. These questions must be determined by evidence concerning the facts in the case, and often by the opinions of men experienced in the particular subject as to the bearing of the facts on the points at issue. It is therefore evident that before litigation is begun, all such facts and the logical conclusions to be drawn from the same should be determined by those who are qualified by learning and experience to judge as to their significance and as to the correctness of the claim which it is proposed to support by legal action.

When the engineer is called in on such matters he should, before he expresses an opinion in regard to the point at issue, determine all of the facts in the case and all of the conditions which surround it and, after careful deliberation and study, deduce the logical conclusions which naturally follow such facts and conditions. Opinions based on an ex parte statement of the matter are often quite misleading and should be studiously avoided and before his final conclusions upon any important questions are rendered he should insist upon the oppor-

tunity of a thorough investigation and a careful consideration of all of the facts and data, and upon a careful examination of the best authorities available. Perhaps the suit itself or at least the results of the suit may depend upon the truth of the opinions he expresses, and in the course of the litigation, if such litigation is undertaken, it is more than likely that any opinion and conclusion which he has expressed will be subject to scrutiny of others equally well informed who will be called on by the other side of the litigation and whose equal duty it becomes to see that the rights of their clients are fully preserved and that justice prevails.

It is obvious that no conscientious professional man will knowingly accept employment which involves an attempt to subvert justice and permit wrong to triumph. It is however frequently the case that technical questions are so involved that there are facts and conditions which seem fairly to warrant the justice of the claims made by both parties to the litigation. It is the undoubted right of each to present disputed claims in the light most favorable to themselves so long as the truth is not perverted and justice is the ultimate aim. For this reason, unless it is evident that the purpose of the client is unfair or dishonest or that his claims are founded on a perversion of facts or incorrect conclusions, there is no reason why he should not be fully entitled to professional aid to the extent that the ends of justice and equity require.

Unfortunately the desire of the client is not always limited to the above ends. Frequently he desires to win his case regardless of law or of equity, and he is not always scrupulous as to the methods employed provided the desired ends are consummated. Not only is this the case, but it is frequently true that personal bias of the client, his attorney and engineers is so developed by their personal interests and their association with the question involved that they are unable to discriminate as to the justice of the case or as to the logical conclusions to be drawn from the facts and conditions. Such bias is but human and may be justly condoned so long as it does not lead to an attempt at fraud or deceit. When carried so far as to create the belief that victory is so desirable that the end will justify any means, it reaches beyond the pale of honorable practice, and employment in such case must be avoided by all conscientious men.

§ 91. Preparation of the Case.—Having convinced himself of the truth and justice of his client's contention, the engineer may be of great value in the preparation of the case for its presentation in court. In this work the engineer must not only fully inform himself in regard

to all facts and conditions affecting the case but he must collect all information and data and arrange and classify the same in such form as will best serve the purposes of presenting the matter to expert witnesses for their examination and for their use in forming their opinions and preparing their evidence, and of presenting the facts to the court during the progress of the case.

The engineer's work will consist of securing and arranging the facts and data pertinent to the case and in devising means and methods by which the facts and principles involved may be so simplified, clarified and presented as to make the conclusions as nearly obvious as possible to the minds of the court or of the jury. Frequently the matter involved may be complicated or of such a distinct and technical nature that it will not be easily understood by those unfamiliar with it or those who are not technically informed. It is often exceedingly difficult to so simplify scientific or technical principles that they may be comprehended by the non-technical and that the logical conclusions may be seen and appreciated. To accomplish this will require all of the ingenuity, ability and knowledge of the professional man. He must endeavor to understand the normal point of view of the judge or jury and so arrange the matter and the material that they, with their limited knowledge and experience in such matters, may be able to grasp the facts and deduce conclusions after the presentation of the technical or scientific principles by the expert witness.

In this connection and prior to the presentation of the case in court, the engineer has first to present these matters in a similar way to the attorney for his client. Here he has an auditor whose normal bias gives him the inclination to accept conclusions favorable to the client but who must normally be shown the logic of the conclusions and be convinced that the facts, conditions and principles as laid out by the engineer are capable of proof and are a proper and scientific method of presenting the case. The engineer must clearly inform the counsel as to the principles involved so that he may properly appreciate the ways and means by which the matter may best be presented. The very need of the engineer in the preparation of the case is due to the fact that the attorneys in the case are working in a field more or less foreign to their common practice and in which, while generally informed, they are ignorant of the details and principles which apply to its more technical aspects. The engineer and counsel must work in unison, for the engineer on his part is normally ignorant of the detailed methods of court procedure, so that the preparation of the case must be carried on by fre-

quent interviews and discussions in order that, by the combined effort of the attorney and engineer, the matter may be presented in the best possible manner.

The engineer may also be of great aid in the selection of expert witnesses whom he knows to be trustworthy, capable, thoroughly informed on the matter involved, and able to present their ideas and opinions in court in such a manner that the judge or jury may be impressed by their learning, ability and honest intentions and understand and appreciate the conclusions which he endeavors to elucidate.

An engineer may also greatly assist the attorney in forecasting, so far as practicable, the probable line of expert testimony which will be offered by the opposite side and by arranging for witnesses qualified to meet it. In general, the attorneys must rely entirely upon their technical adviser in such matters.

§ 92. **Examination of Technical Witnesses.**—An engineer who has thoroughly studied the subject and fully appreciates the principles involved and the essential ideas which it is desirable to develop in order to properly present the matter to judge or jury, can be of great value as an adviser both in the direct and in cross examination. On principles that are well established, the same answer will undoubtedly be given by the expert witness of either party. On questions depending on opinion such answers may differ largely. No matter how honest the expert witness may be, he is not allowed to volunteer information and can give an answer only when a proper question is propounded. It is practically impossible for one unfamiliar with the technical matter at issue to so frame questions that they will necessarily involve the answer sought, and many technical cases have been lost by the inability of the attorneys to understand and bring out the facts and principles at issue (see Sec. 51) even from their own witnesses. The difficulty is accentuated in the case of cross examination where the opposing witness, who is often more or less antagonistic, must be made to give the answer desired by a carefully framed question which will admit of no alternative. Technical cases have been won purely on cross examination of opposing witnesses by attorneys well versed in the subject under litigation and advised by competent experts.

§ 93. **The Expert Witness.**—The selection of an engineer, expert in his specialty, is a matter of great difficulty (see Sec. 111); but the selection of an expert witness is even more difficult, for a man may be thoroughly informed in his specialty, competent to design and construct and yet may be unsuitable to present his ideas and opinions in

court in such a manner that the judge or jury will understand the technical principles involved and the conclusions which logically follow from the facts and conditions.

"Unfortunately the average technical man cannot explain his work so a layman can understand it; the average engineer has this fault in an unusual degree, and the successful presentation of his testimony may be a matter of considerable training, in order that he will drop his technicalities and details and stick solely to the essentials of the case. If he will tell his story for his own side so that it can be understood, his inability to explain himself clearly under the cross-examination of the opposing counsel may be safely left to work itself out." (Eng Rec. Vol., 60, p. 141.)

"There is nothing unprofessional in the initial presumption of an engineer that a prospective client's interest justifies professional defence, or in exerting his best efforts in making that defence even though there may be more or less doubt involved. In fact, that doubt is just what should be turned into a certainty in favor of the client if possible. If, on the other hand, it is clear that the technical position taken by the client is indefensible as an engineering proposition, any engineer would be recreant to his professional principles if he did not plainly and unqualifiedly advise that client of the erroneous position assumed by him. This is by no means an uncommon experience. There probably are few engineers who have had much consultation experience who could not name a considerable number of cases where the only true professional course has been to advise an emphatic negative to propositions where an encouraging affirmative was confidently expected. There is, however, no evading this kind of responsibility. As a professional man he is bound by the highest professional obligation to place his best judgment and knowledge at the service of those who seek him, whether the result favors the contemplated project or not. It is as much his duty to tell a client that he is wrong, if he is wrong, as to tell him he is right when he is right." (Eng. Rec. Vol. 57, p. 737.)

Not only are the parties to litigation frequently wrong in their views of the rights and principles involved, but too often a deliberate attempt is made to bolster up an unjust case by biased evidence.

"One of the leading American constructing engineers was asked to serve as an expert witness in an important suit. He had the usual aversion to such work, but the prominence of the parties asking him to serve was so great that he did not care to decline outright. He accordingly named an excessive fee and expected the matter to drop there. To his

astonishment the fee was immediately approved and the lawyers visited him to explain the case and state just what he was expected to testify. He protested that the testimony would be seriously incorrect technically, but he was then informed that such things were really matters of judgment and the very large fee he was to receive was for the purpose of showing to the court that the desired opinions were held by an eminent engineer. If he changed his views after the case was settled it would be a matter of indifference to the lawyers and their clients. It is hardly necessary to say that the engineer did not see the matter in the same light." Eng. Rec. Vol. 62, p. 533.

It is said that in the early courts of Rome there were certain individuals who wore straw in their shoes; this was to signify that they were prepared to go into court and swear to whatever conditions their clients might desire. There are very few men in the ranks of the engineering profession, and those who do appear soon sink into the oblivion they so justly merit. No man in any profession who blinds his conscience in favor of unrighteousness can hope to attain that respect and eminence which should be the object and desire of every man.

In numerous legal proceedings of the same class, it is common to find certain individuals uniformly representing one aspect of the same question. For example in the condemnation of public utilities, certain experts if employed are uniformly employed on the part of municipalities while certain others are as uniformly employed only on the side of utilities. This is due not necessarily to dishonesty but to a certain bias of the individual judgment that makes his testimony of greatest value to the side which he commonly represents.

This bias may be more or less radical and is often the result of peculiar experience or a one sided point of view, and in many cases the opinions of such parties would be radically changed if they were called upon to carefully consider the subject from a different aspect.

It may be added that whenever an honest and conscientious engineer finds himself repeatedly called to sustain a certain definite point of view in a variety of similar cases, he will do well to carefully analyze his position and examine the basis of his opinions and determine whether his conclusions are not being radically affected by the limitations of his experience and affiliations rather than by any profound knowledge of the subject.

§ 94. **Qualifications.**—In order to be competent as an expert, the witness must show that he possesses knowledge or skill in the matter on which his evidence is desired. His qualifications may depend on

observation, experience or study. The extent and nature of the practice and experience which can be shown to peculiarly qualify him for a proper judgment of the matter at issue will often greatly affect his value as a witness. His qualifications are usually demonstrated by an examination preliminary to his admission as a witness, in which he is given opportunity to explain his knowledge and experience, his opportunities for observation and investigation, and such other facts as may demonstrate his fitness. His admission as a witness is largely within the discretion of the court.

§ 95. **Expert Evidence.**—In general the opinions of witnesses are inadmissible as evidence and are considered irrelevant. The exceptions to this rule are in those cases where the opinions of experts are received, and such cases are confined to subjects beyond the knowledge of men of ordinary education and experience.

In many cases where the subjects of litigation are wholly unfamiliar to the judge or jury, the admission of expert testimony is the only adequate method of arriving at substantial justice. Nevertheless such evidence is often justly considered of little credence or value.

“The evidence of experts is of the very lowest order and the most unsatisfactory character.” ¹⁴

“It is the inherent infirmity of expert testimony that it consists largely of matters of opinion in addition to those elements of weakness and uncertainties which enter into the testimony of those who relate simply what they have seen or heard. We have, in expert testimony, the deductions and reasoning of the witnesses with all the chances of error incident to human reasoning. The notorious fact that experts of equal credibility and skill are found in almost every important case, testifying to directly opposite conclusions, illustrates both the fallibility of such testimony and the fact that a conviction for perjury based upon such evidence would be very difficult. It is a matter of common observation in the courts that witnesses of the highest character and of undoubted veracity may be easily lead as experts to espouse and defend a theory with all the zeal of the advocate.” ¹⁵

“Lord Campbell, in the case of the Tracy Peerage (10 C. & F. 154, 191), placed on record his judgment of the worthlessness of the system which would fain evoke a judicial answer or opinion from a human being whose preparation for thus thinking and speaking had been a life

¹⁴ Whittaker v. Parker, 42 Iowa 586.

¹⁵ Jones on Evidence, 2d Ed. Sec. 390.

of weeks or months, may be in the environment which ordinarily falls to the lot of the advocate; not to speak of the futility of expecting to get such an opinion from a man placed in the witness stand, and condemned to say naught but in answer to ingeniously concocted, perhaps more or less rasping questions. "I do not mean," said Lord Campbell, "to throw any reflection on Sir Frederick Madden. I dare say he is a very respectable gentleman, and did not mean to give any evidence that was untrue; but really this confirms the opinion I have entertained, that hardly any weight is to be given to the evidence of what are called scientific witnesses; they come with a bias on their minds to support the cause in which they are embarked; and it appears to me that Sir Frederick Madden, if he had been a witness in a case, and had been asked on a different occasion what he thought of this handwriting, would have given a totally different answer."¹⁶

Much that is similar to the above has been said from the bench and by writers on Evidence in criticism of expert testimony and some radical change is undoubtedly desirable in judicial procedure in order that such testimony may be utilized to conserve the ends of justice. It is too much to expect however that this will ever be accomplished so long as the courts must depend either upon the presentation of evidence by experts employed by the opposing parties in the case who from the nature of the judicial procedure are more or less biased in favor of their client, and are not permitted, even if they so desire, to express their competent and unbiased opinion on the subject. The questions asked are so framed as to command the answers given, and the nature of the cross examination is usually an endeavor to confuse the witness, belittle his ability, prove the falsity of his opinion and as a result arouse the antagonism which is detrimental to the ends of justice.

Expert witnesses are but human and humanity is not infallible even when clothed in the garments of the court. Our highest tribunals are closely divided on judicial opinions, and many cases are decided by bare majorities, showing that entirely disinterested and fair minded judges are not able to arrive at unanimous decisions. In other cases judicial decisions have been rendered by jurists whose interests or connections have been such as to so bias their judgment that their impeachment resulted as a consequence of glaringly erroneous decisions. Even the supreme court of the United States decided the Tilden-Hayes Pres-

¹⁶ On the Best Manner of Making Use of the Services of Experts in the Conduct of Judicial Inquiries, by Clemens Herschel. Eng. News, Apr. 9, 1887, p. 234.

idential controversy on purely political lines, and numerous cases might be cited both of the supreme court and of lower courts where the decisions have resulted from pure bias. The fact that such bias may and sometimes does exist, is recognized by the provisions of the law which permits attorneys on a presentation of a sworn statement of prejudice to seek another jurisdiction for the trial of their case.

In a recent case in one of our states, in which a very important public question had aroused considerable public controversy, a special court made up of seven judges, after hearing extended evidence on the subject, decided the matter on purely political lines. There was not one of the judges acting in the case but that, on the final ballot, voted from the point of view which was most popular in the district which he represented.

It is evident that in the nature of cases requiring expert testimony, such testimony will be arranged beforehand and that neither side will call witnesses whose testimony will be detrimental to their interests. It is obvious that under these circumstances the expert witness has already expressed his opinion on the subject and that such opinion is favorable to his client. In many cases this opinion has been due not only to a careful consideration of the facts and data available but to a long and exhaustive examination and consideration from the point of view of the client. Under such circumstances it is certain that the expert will be interested on his client's side of the case and will ordinarily desire its success. He is moreover under certain obligations for employment by his client and under such circumstances his judgment cannot be altogether unbiased. While this condition has its objectionable features, it is equally true that it is not without its advantages. This partisanship is not without its use in the ultimate triumph of equity and justice, for it leads to a most careful scrutiny of the case in an endeavor to bring out all of the points which tend to demonstrate the justice of his client's claim, and it is doubtful if this could be accomplished by the unbiased investigation of an entirely disinterested expert.

"The thoughtless observer of a trial is likely to draw the impression that the representatives of each side are monumental liars, but this opinion is generally entirely wrong for three reasons, one being that most witnesses testify merely from memory without the help of a diary, another being that the lawyers often succeed in preventing a witness from telling the whole truth, and the third being that where the divergence of views between two parties was a matter of slow development and the case was a long time in coming to trial, the recollections of the various

parties must inevitably be tinged by their own interests and not those of their opponents. The court and jury are consequently obliged to take this mass of conflicting evidence and ascertain as far as possible by the preponderance of creditable testimony on which side justice probably lies, or whether both parties are not partly wrong and partly right, which last condition is almost always the case. If the dispute involves technical features it is evident that greater complexity is introduced, because here conditions which are not within the knowledge of most men must be thoroughly understood before a case can be equitably decided."—Eng. Rec. Vol. 60, p. 141.

§ 96. **Desirable Reform of Procedure.**—From the previous consideration of the matter, it is evident that the present status of expert testimony must be regarded as largely normal and nothing more than what should reasonably be expected. It is only the part of wisdom therefore that the procedure in such cases should be corrected along the lines which will utilize the beneficial results of the present system of introducing expert evidence and offset its disadvantages by the use of the expert or board of experts as the adviser of the court.

It is not desirable that the present system be entirely dispensed with or that the freedom of the parties to present any competent testimony be abridged. It has occasionally been advocated that no experts should be heard except those appointed by the court, but it is a fact beyond question that the courts are not as a rule competent, in this day of narrow specialties, to select experts adequate to properly bring out all of the points at issue, and are otherwise so subject to human weaknesses that such appointments would not be beyond the pale of personal and political influence.

In the judicial procedure of cases of expert evidence, what is needed at the present time is not that the expert should be chosen by the court but that the court should have expert advisers who are able to properly weigh the testimony submitted and to differentiate on the basis of their scientific or technical knowledge of the subject the true from the false, the essential and the non-essential, and to draw correct conclusions from the mass of evidence which is frequently beyond the capacity of the presiding judge or of the jury.

§ 97. **Appraisal of Public Utilities.**—In the appraisal of public utilities, the same difficulties are encountered as in other procedures for the determination of technical matters by expert testimony. Before the appointment of state public utility commissions, it was the general practice, usually as specifically provided in the franchises, to appoint a

board of three or five appraisers for the purpose of determining the values of the properties. In some cases the acceptance of the findings was optional and in other cases obligatory. In the majority of such cases engineers were appointed for this purpose. Each party to the proceeding appointed one or two, and those so appointed elected a third or fifth person as chairman. In these cases almost without exception the experts appointed by each party exhibited more or less of the bias due to such appointment (see Sec. 12) and with few exceptions acted as advocates for the client to whom their appointment was due. The third or fifth member being independent of either party in his appointment, fulfilled the function of judge or umpire and adjudicated the differences of opinion and ultimately the findings of the board. In the majority of cases the members of such boards undoubtedly endeavored to overcome their bias and to render substantial justice, but the effect of their appointment was almost universally apparent.

In the few cases where such commissions were entirely free from this *ex parte* character, the differences were immediately apparent and the results were far more satisfactory.

There is no doubt that the appointment of State Public Utility Commissions for the fixing of values and rates is in principle a move in the right direction. The main difficulty has been that in many cases such appointments have been more or less political and such boards have usually been constituted of judges, lawyers, economists and statisticians of greater or less ability but with no particular aptitude for the work in question. Some commissioners, while nominally unbiased, have in fact felt that they held a brief for the people and were appointed to see that the rights of the people were safeguarded and preserved. This bias has often resulted in findings which were unjust and inequitable. Where however they have continued long in office, they have usually gained a good insight into their real duties and the justice and equity of their findings have greatly improved. It has been unfortunate that such boards have not been uniformly constituted with, at least one technical member who possessed real practical experience in the construction and administration of such properties. In most cases these commissions have employed a corps of technical advisers, but in general from lack of funds or of an appreciation of the requirements of the cases, they have secured young professional men of little experience or special technical knowledge, with results which would naturally be expected from estimates and findings based simply on theory.

Even where technical aid has been employed, it has not been utilized in such a manner as to secure the best results. Usually estimates

have been prepared by the corps of the board and submitted to both parties prior to the hearing.

At the hearing *ex parte* expert evidence has been heard by means of which attempts have been made either to reduce or increase certain items of the estimates which it was considered desirable to contest. Those items which were satisfactory because actually too high or too low were not contested. The corps of the board having once filed their values are only more firmly convinced by the attack of both parties of the justice of their findings, and are driven to correction only when their position is shown to be untenable.

Every consideration of the nature of expert evidence and of human nature would logically require that all evidence by the expert witness of the two parties to the case first be presented after which the evidence should be considered, investigation made, and a finding reached by the experts of the commission. This arrangement would undoubtedly result in more just and equitable findings than under the conditions now widely extant.

§ 98. **Professional Duty.**—The true aim of the profession of engineering is the establishment of truth. If the engineer, by his special knowledge, can assist in the establishment of justice he has a duty to perform that cannot be laid lightly aside.

“If he is true to his profession, he will always give the results of his study, whether it bears for or against the side upon which he happens to be called. If he is not prepared to do that, or if the circumstances of the case prevent it, then he is in duty bound to decline, or refuse to render his services. This he may not always do; but if compelled to attend against his wishes, he cannot be said to be under any obligations to either party to the suit, and may exercise his honest judgment, without prejudice or criticism.”¹⁷

In accepting service as an expert witness, the engineer owes it to himself, to the public and to his profession to restrain his personal bias, retain his high ideals, and to lend his services only to the support of truth and justice.

“The Golden Rule applies in expert testimony as every where else. Translated for this occasion this might say ‘Do not make statements in giving testimony which you would not be willing to support before any gathering of engineers.’ ”¹⁸

¹⁷ Engineering and Architectural Jurisprudence, Wait, Sec. 874, pp. 797–98.

¹⁸ Frank H. Watermann in discussion on Expert Evidence before the American Institute of Consulting Engineers, Oct. 25, 1912.

LITERATURE

Engineering and Architectural Jurisprudence. John Cassan Wait, John Wiley & Sons, New York.

The Law of Evidence in Civil Cases. Burr W. Jones, Bancroft Whitney Co., San Francisco.

Engineering and the Law. Discussion of origin and growth of the profession and of law. Frank P. Medina, Jour. Assoc. Eng. Soc., 1905.

Engineers and Architects, Their Power and Duties Considered from a Legal Standpoint. A discussion of Engineering Law. J. C. Bradford, Trans. Eng. Assoc. of South, Vol. 8, p. 10, 1897.

Legal Engineering, Advantages of Lawyer Having Training in Engineering. Editorial, Eng. Rec. Vol. 66, p. 650.

Legal Liability of Architects and Designers. Robert N. Miller, Rose Technic, Vol. 25, p. 117.

Expert Evidence. A discussion before American Institute of Consulting Engineers by Various Engineers. Pamphlet, Office of Secy., 101 Park Ave., New York. See also Eng. Rec. Vol. 66, p. 542.

The Engineers Responsibility as an Expert. Editorial. Eng. Rec. Vol. 57, p. 737.

Engineering Services and Court Cases. Editorial. Eng. Rec. Vol. 60, p. 141.

The Expert Witness. Editorial. Eng. Rec. Vol. 62, p. 533.

On the Best Manner of Making Use of the Services of Experts in the Conduct of Judicial Inquiries. Clemens Herschel. Eng. Rec. Apr. 9, 16-23, 1887.

The Scientific Expert in Forensic Procedure. Prof. Chas. F. Himes, Jour. Frank. Inst. June 1893.

The Engineer as a Witness before the Courts. Jesse M. Smith. Sibley Jour. of Eng. Vol. 20, p. 265.

The Surveyor in the Presence of the Court. Prof. J. C. Knowlton. Mich. Eng. Soc. Jan. 1901.

CHAPTER IX

NOTES ON AGREEMENTS AND CONTRACTUAL RELATIONS

§ 99. Definitions.

An agreement is the expression of two or more persons of a mutual intention to effect the legal relation of those persons. The term is broader than the term *contract* and may include:

1. An agreement resulting in a contract. This is an agreement which directly contemplates the creation of obligations.
2. An agreement immediately concluded that creates no obligation. For example, conveyances of land without covenants; gifts, sales and delivery of chattels for cash without warranty, etc. These are sometimes called *executed contracts*.

3. An agreement concluded, with incidental or remote obligations; for example, marriage; a settlement of property in trust, etc.

A *legal obligation* is a private legal control which can be exercised by a certain definite person or persons over a certain definite person or persons for the purpose of compelling certain definite acts or forbearances which must possess or be reducible to a money value.

An *executory contract* is a legal obligation created by agreement and enforceable by an action at law; it is one in which at least one of the parties has something more to do.

An *executed contract* is one in which both parties have done all that they agreed to do.

A *bi-lateral contract* is an executory contract consisting of an express promise of one legal right given in exchange for a counter promise of another legal right.

Example.—A offers to perform certain services for B for a given amount and B accepts this offer, promising thereby to pay said amount for A's services; the latter's promise accepts the former's offer of a promise and creates a bi-lateral and express contract.

An *express contract* is a bi-lateral contract either oral or in writing, all of whose terms are accepted.

An *uni-lateral contract* is a half-executed, half executory contract, consisting of an express or inferred promise of one legal right for another legal right.

Ex.—If A offers a definite reward for the return of a lost article, and B, acting on the offer, returns the lost article, B's act accepts A's offer and

creates an uni-lateral and inferred contract, giving B a right to the reward offered.

An *inferred contract* is an uni-lateral contract where either the act of acceptance, or both the act of acceptance and the promise offered are inferred.

Ex.—The owner of a street car system by running his cars along the city streets, offers by inference the facilities of transportation to the public. B in entering the street car accepts such offer by inference and thus creates an inferred contract.

A *quasi-contract* is a legal obligation created by pure implication of law. It is not a contract but may be enforced by legal action.

Whenever a benefit has been received by one person which in equity belongs to another person, the law implies an obligation on the part of the former to refund the same, and permits the latter to recover its value by an action at law.

Ex.—If A requests B, an engineer, to render a certain professional service for him, there being no express or inferred agreement as to remuneration, B is, nevertheless, entitled to recover for the value of his services, as the law implies an obligation to pay therefor.

A *joint contract* is one in which either the promisors are jointly bound, or the promisees are jointly entitled to the performance of a legal obligation.

Ex.—If a promise is worded "We promise to pay \$100 to X and Y" and is signed by A and B, the latter are jointly liable, and the former jointly entitled to the payment.

A *several contract* is one where either each promisor is individually liable or each promisee is individually entitled to the performance of a legal obligation.

Ex.—If a promise is made in the words "We severally promise to pay \$100 to X and Y to be equally divided between them," is signed by A and B, the latter are severally liable, and the former severally entitled to the payment of half the amount due.

A *joint and several contract* is one where the promisees may elect to hold the promisors either jointly or severally bound to perform a legal obligation.

Ex.—If the promise is worded "I promise to pay to X and Y" and is signed by A and B, the former jointly may hold the latter either jointly or severally liable to pay the amount.

A *written contract* is an express contract evidenced by writing.

A *specialty* is an express written contract under seal.

Ex.—A agrees to sell B a horse for \$100 and B agrees to pay that amount for the horse. If the agreement is signed under seal it is a specialty or deed. If no seal is used, it is a written contract and enforceable provided B at the same time the agreement was made, pays a part or all of the purchase price.

An *oral contract* is an express contract without other evidence than the spoken word.

A *valid contract* is one whose obligations are binding upon both parties to the agreement.

A *void agreement* is one which creates no obligation.

A *voidable contract* is one whose obligation is not binding upon one party to the agreement, at his election.

An *agreement of imperfect obligation* is one which is incapable of enforcement, but otherwise valid.

Ex.—If A agrees to work for B for \$100 per year, and they sign a written agreement to that effect, the contract is a valid contract if both parties have complete contractual capacity.

If A is a minor, or other party lacking the capacity to contract, or if the contract is procured by fraud, it is a voidable contract.

If the work which A agrees to perform is unlawful, the agreement is void.

If B does not pay A for his services, and A waits more than six years after performing the work before suing, or if B is discharged by proceedings in bankruptcy, or if the agreement is not in writing to satisfy the statutes of fraud, the agreement is valid but unenforceable.

The contract in which the engineer is most frequently interested is the *express executory contract*, which has been defined as follows:

"A contract is an agreement in which a party undertakes to do or not to do a particular thing."—CHIEF JUSTICE MARSHALL, 4 Wheaton (N. C.) 122, et seq.

"Contract is that form of agreement which directly contemplates and creates an obligation."—SIR WILLIAM R. ANSON.

"A contract is a promise to do or to refrain from doing some act which the law will enforce."—PROF. J. B. JOHNSON.

"A contract in the widest sense of the term, is an agreement whereby at least one of the parties acquires a right in relation to some person, thing, act, or forbearance."—PROF. R. M. BENJAMIN.

"A contract in a narrow sense is an agreement whereby at least one of the parties acquires the right to an act or forbearance on the part of the other. The obligation assumed by the other is called a promise."—PROF. R. M. BENJAMIN.

§ 100. Express Executory Contract.

Express executory contracts may be of two kinds:

I. *Contracts under seal or specialties.* Contracts under seal are more formal and of a higher order than parol contracts, and formerly had greater force and effect in law, so great, in fact, that an executory agreement could be made binding only by a contract under seal. The seal imported a consideration and rendered proof unnecessary. The presumption was that an agreement executed with so much solemnity

and deliberation was founded upon sufficient cause. The seal has, however, lost much, and in some cases in America, all of its former force; and in some states it has no significance.

Under the common law, which as noted above, has in some cases been modified by statute, the following agreements must be executed under seal:

1. Gratuitous promises.

2. Contracts with corporations (no longer necessary unless specifically so provided in the corporation charter).

3. Deeds and mortgages (unless otherwise provided in the statutes of the state).

4. Bonds.

II. Contracts not under seal, whether written or oral, are termed *parol contracts*.

§ 101. Requirements of a Valid Contract.

The requirements of a valid contract are:

- I. Two or more parties with capacity to contract.

- II. An offer and acceptance.

- III. A consideration.

- IV. Legality of object.

- V. Reality of consent.

- VI. A writing (whenever required by the statute of frauds).

§ 102. Parties with Capacity to Contract.

- I. A man cannot enter into contract relations with himself of such nature that it will be enforceable by law.

A contract must therefore have at least *two parties*.

- II. The following persons are incapable under certain circumstances of entering into a valid contract:

1. Minors.

2. Persons of unsound mind.

3. Drunken persons.

4. Persons under conservators.

5. Corporations.

6. Agents.

1. *Minors*. At common law, a person under the age of twenty-one is a minor.

A. A minor can bind himself for *necessaries*. The term *necessaries* includes all articles and services that are reasonably necessary to supply the personal needs of a person in the minor's circumstances, including food, clothing, lodging, medical and legal aid, instruction, etc., of quality and quantity suitable to his condition of life.

B. The contract of a minor, unless made for necessities or under the authority or direction of the statutes, is voidable in his favor. Such a contract is binding on an adult person who has entered into such a contract, but voidable on the part of the minor.

C. Such contracts may be avoided by the minor either

(a) During minority, or

(b) Before ratification after attaining majority.

D. Such contracts may be confirmed by the minor after attaining his majority by

(a) Express ratification.

(b) By acts which clearly show his intention to confirm the contract.

(c) By omission to disaffirm the contract within a reasonable time if such omission is prejudicial to the interests of the other party, or within the statutory period of limitation.

E. If a minor avoids a contract on which he has received money or property, he must restore it if it is in his power to do so.

F. Where a minor has performed service in partial or entire execution of an express contract, and he avoids the contract, he may recover the value of the services rendered on an inferred contract.

2. *Persons of unsound minds.*

A. A person of *unsound mind* may bind himself for necessities.

B. A contract other than for necessities made by a person who is of unsound mind is voidable in his favor.

C. A contract made with such a person in a lucid interval is binding.

D. When such persons, not under conservator, are apparently of sound mind, and the other contracting party has reasonable cause to believe otherwise, the contract cannot be avoided if it is fair and has been so far performed that the party cannot be restored to his former position.

3. *Drunken persons.*

A. A *drunken person* can bind himself for necessities.

B. Contract for other than necessities, made by a person so drunk as to be incapable of understanding its nature and effect, is voidable in his favor.

C. A less degree of drunkenness does not render the contract voidable unless the circumstances justify the inference that it was obtained by fraud.

4. *Persons under conservators.*—Persons for whom conservators have been appointed on account of feebleness of mind, drunkenness, idleness or debauchery, are limited in their contractual capacity in a manner similar to minors, persons of unsound mind and drunken persons.

5. *Corporations.*—Municipalities and business corporations.

A corporation is an artificial person created by law and has the capacity to make contracts within the scope of the powers conferred upon it by the act of incorporation, but to that extent only.

A. A valid contract with a corporation must be:

(a) Within its corporate powers.

(b) Authorized by its legally governing body.

(c) Entered into by the official or officials properly authorized.

B. Unless restricted by its charter, a corporation can make any contract within the scope of its powers in the same manner and under the same circumstances as a natural person. It may even be liable on an implied contract.

C. A contract is within the powers of a corporation when it is necessary or reasonably incidental to the purposes for which the corporation was created, and is not expressly prohibited.

D. If the contract has been performed by the other contracting party, and the corporation has actually received benefit therefrom, it cannot withhold payment therefor on the ground that it was not empowered to make the contract, although such contract may not be within the scope of the powers conferred upon it.

6. *Agents.*—A person legally competent may act through a duly appointed agent. In such cases the agent will have the following powers and limitations:

A. The acts of the agent will make the principal responsible for the exercise of all powers duly conferred or which may be fairly implied.

B. The acts of the agent without the actual authority or appearance of authority of the principal does not bind the principal unless subsequently ratified by him.

C. To bind his principal by an instrument under seal, the agent must have authority under seal, except:

(a) When the instrument is sealed in the presence of the principal and by his authority.

(b) Where the instrument would have been valid without seal.

(c) Where a corporation by resolution of its governing board without seal authorizes the execution of the instrument under seal.

D. An agent cannot represent a principal to whose interests his own are antagonistic.

E. The authority of public officers and agents are matters of public law and record of which all parties are legally bound to take notice.

In all cases of possible incapacity, there are certain well defined limits where the capacity to contract is undoubted and equally well defined cases wherein the incapacity to contract is equally obvious. Between these obvious limits great uncertainties may exist, and the ability or inability may be a question involving proof of conditions, the point of view of the local courts, which often differs radically in different locations, or the opinion of a jury who may judge from such evidence as may be presented and which may not be apparent at the time the contract is made. Those who enter into contracts with persons who may possibly not possess the capacity to contract, undertake such contracts at their peril and such contracts should therefore be confined to such limits as are clearly within the legal capacity of the parties.

§ 103. Offer and Acceptance.

I. The offer must be clear and absolute, and must manifest an intention to create or to change legal relations.

1. An offer may be revoked at any time before acceptance, except when:

A. A definite option, for which a valuable consideration is given, is granted.

B. The offer is made in answer to a request for proposals to be accompanied by a deposit, certified check or bond, to be forfeited as liquidated damages for failure to enter into contract obligations, if the proposal be accepted. In this case, the opportunity of submitting the proposal, the expense incurred by the preparation of plans, by advertisements for proposals, by furnishing plans and specifications, and by other acts of the first party, are sufficient considerations for the exercise of the option to retain the privilege of accepting or rejecting the proposal for a certain specified or for a reasonable time.

2. An offer may elapse before acceptance.

A. By expiration of a prescribed time for acceptance.

B. Where no time is prescribed, by the expiration of a reasonable time for acceptance.

C. By failure to comply with the prescribed conditions, as to the mode of acceptance.

D. By the death or insanity of either party.

II. The acceptance must be clear, absolute, identical with the terms of the offer and with the intention of creating legal obligations.

An acceptance upon terms varying from those proposed by the offer is a counter-proposition, and is not binding until it is itself accepted. Such a counter-proposal is a virtual rejection of the original offer, and since the offer when rejected is at an end, a subsequent acceptance of the original offer can operate only as a new counter-proposal which, like the original offer, may be either accepted or rejected.

III. 1. An agreement is not a contract unless its terms are certain or capable of being made certain.

2. Either the offer or the acceptance may be expressed by conduct or words. Performance of the conditions of an offer, or the acceptance of the consideration proffered is an acceptance of the offer.

3. An offer need not be made to a definite person, but no contract can exist until the offer has been accepted by a definite person.

4. Where the parties communicate by means beyond their control, as by mail, the contract is complete the moment the acceptance is dispatched, provided this is done in due time after receipt of the offer and before notice of withdrawal is received.

§ 104. Consideration.

In every contract containing a promise, there must be a *consideration* for the promise, except in the case of certain contracts under seal or negotiable, the form of which imports the consideration. In such cases, the want of a consideration may be pleaded and proved, except against a bona fide assignee (or innocent purchaser) of a negotiable contract, purchased and assigned to him before it came due.

A contract is said to be negotiable when it can be so transferred that the assignee has the right to sue upon it at law in his own name. (Bills of exchange or promissory notes.)

A bona fide assignee is an innocent purchaser for value to whom the negotiable paper has been sold and assigned without notice of the want of a consideration.

I. The consideration need not be adequate to the promise but it must have some value. So long as the promisor gets what he has bargained for and without claim of fraud or undue influence, the court will not inquire into the adequacy of the consideration.

II. When at the request of the promisor, the promisee confers or promises to confer any benefit upon the promisor, or incurs or promises to incur any detriment, and such detriment, benefit or promise is

the inducement for the promisor's promise, it is a sufficient consideration for the promise.

III. The abandonment of any legal or equitable right against the promisor or against a third party, or the forbearance to exercise it for a definite or reasonable time is sufficient consideration for a promise; so is the compromise of a disputed claim honestly made, although it ultimately proved to be unfounded.

IV. The delivery of property in trust to a person is sufficient consideration for a promise to execute the trust.

V. Blood relationship, natural affection or moral obligations are not sufficient considerations to support a promise.

VI. A promise whose performance is impossible in itself or impossible in law, is not sufficient as a consideration; neither is a promise to do or actually doing what one is legally bound to do.

VII. A past consideration will not support a subsequent promise, for such a promise is purely a gratuity only.

Exceptions.

1. If a request is made and a consideration granted, and the request under the circumstances reasonably implies the promise of recompense, such promise can be enforced.

2. If one without request voluntarily does on behalf of another that which the other was legally bound to do, the act may be ratified by the latter by a subsequent promise of recompense, and such ratification will be equivalent to a previous request in supporting such promise.

3. When under the law a promise for a valuable consideration cannot be enforced against the will of the promisor, he may, subsequently, if of full capacity to contract, renounce the benefit of such law by renewing his original promise.

§ 105. Legality of Object.

An agreement, the object of which is forbidden by law or opposed to public policy, will not be enforced by the court. The performance or omission of an act may be forbidden by express prohibition or by implication.

The principal classes of agreement opposed to the law or to public policy are those:

- I. Which tend to injure public service.
- II. Which tend to obstruct the course of public justice.
- III. Which tend to encourage litigation.
- IV. Which involve immorality.

- V. Which unduly affect the freedom or security of marriage.
- VI. In unreasonable restraint of trade.
- VII. To suppress competition at letting, or at sale by auction.
- VIII. To submit to arbitration.
- IX. To pay usurious interest.
- X. To submit to unjust penalties.

§ 106. Reality of Consent.

Consent is not real when it is caused by mistake, misrepresentation, fraud, duress, or undue influence.

I. *Mistake* is a ground for avoiding a contract where it is:

- 1. A mistake as to the nature of the transaction in the absence of negligence operating as an estoppel.
- 2. A mistake as to the person with whom the contract made.
- 3. A mistake as to the existence or identity of the subject matter of the contract.

A contract cannot be avoided on the ground of a mistake as to any law in force in the state.

II. *Misrepresentation* as distinguished from fraud is ground for avoiding a contract when it consists in a statement or non-disclosure of the following character by one of the parties reasonably relied upon by the other and inducing him to enter into the contract.

- 1. Untrue statement of the material fact believed to be true by the one making it.
- 2. A non-disclosure of the material facts by one under a special obligation to make the disclosure by reason of the fiduciary nature of the contract or the confidential relation of the parties.

III. *Fraud*.—Fraud as a ground for avoiding a contract consists in any of the following acts committed by one of the parties or with his connivance, and with intent to induce the other to enter into the contract, and which is reasonably relied upon by the latter, and actually induces him to enter into the contract.

- 1. A false representation of material facts by one with knowledge of the falsehood, or a representation made in reckless disregard of what may be true.
- 2. The actual concealment of a material fact by one with knowledge or belief of the fact.
- 3. Any other act fitted to deceive.

IV. *Duress*.—Duress, as grounds for avoiding a contract, consists in any of the following acts committed or threatened by one of the parties or with his connivance, and causing the other to enter into the contract.

1. Unlawful imprisonment of the other party or of his wife, parent, or children.

2. Imprisonment of such party, procured through the abuse of lawful process or made unjustly oppressive.

3. Unlawful and great bodily harm to such party.

4. Unlawful seizure, detention or destruction of the property of such party.

V. *Undue Influence*.—Undue influence as grounds for evading a contract may obtain where one of the parties induced the other to enter into the contract by the unconscientious use of power afforded by

1. Parental fiduciary or confidential relations.

2. Mental weakness of the other.

3. Necessity or extravagance of an expectant heir or one sustaining that character.

§ 107. Statute of Frauds.

No contract within the provision of the statute of frauds is enforceable at law, unless such contract or some memorandum thereof is in writing, signed by the party to be charged thereby, or by his lawfully authorized agent. Such contract or some memorandum thereof must show who are the parties thereto and what is the promise sought to be enforced.

A verbal contract within the statute is voidable but not void.

The written contract or memorandum need not be signed by the other party to the contract; a written offer, verbally accepted, is binding upon the signer.

The following promises are within the statute of frauds:

1. A special promise of an executor or administrator to answer any debt or damage out of his own estate.

2. A special promise to personally assume the debt, default or mis-carriage of another person.

3. An agreement made upon the consideration of marriage.

4. Certain agreements not to be performed within the space of one year from the making thereof.

5. A contract for the sale of land, tenements or hereditaments, or the disposal of any interests in them for a longer period than one year. Such contracts if made by agents are not enforceable at law unless the authority of the agents is also in writing and signed by such party.

§ 108. The interpretation of Contract.

When the meaning of a contract is in doubt, the leading rules of construction which govern its interpretation are as follows:

I. *In general*.

1. Where no doubt exists, there is no room for construction.
2. Impossible things cannot be required.
3. The controlling consideration in construction is to discover the mutual intentions of the parties. With this object, the subject matter, context, and the object, precedence, consequences, causes, effects, and conditions of the parties to the contract must be examined to determine their intention.

II. *As to the meaning of words.*

1. The words of a contract are to be construed with reference to its subject matter and the circumstances under which it was made. They are to be taken as those who used them intended.
2. When words have more than one sense, that agreeable to law must prevail.
3. Words inconsistent with the nature of a contract or with the intention of the parties, will be rejected.
4. The words are to be taken in their ordinary and popular sense, unless by the usage of trade, etc., they have acquired a peculiar sense in regard to the matter considered.
5. Technical words, unless clearly used in another sense, are to be interpreted as usually understood by the persons in the profession, business or trade to which they relate.
6. Broad wording will not extend a contract to those things concerning which it is apparent the parties did not intend to contract.

III. *Inconsistency.*

1. Several writings between the same parties, if they relate to the same subject matter and are substantially parts of one transaction, must be taken and construed together as one contract.
2. Where the terms of the contract, partially written and partially printed, are inconsistent, the written part will control the printed.
3. Words inconsistent with the nature of a contract or with the intention of the parties, will be rejected.
4. When no doubt exists as to the meaning of a contract, the construction which the parties to it have practically given it by their act, carries great weight.
5. In case of doubt, the language of a contract is taken most strongly against the party using it, except when this would cause penalty or forfeiture.

§ 109. **The Discharge of Contract.**

A contract may be discharged:

- I. By agreement between the parties.

- II. By contract provisions.
- III. By performance.
- IV. By impossibility of performance.
- V. By operation of law.
- VI. By breach of the contract.
- VII. By the discharge of the right of action.

I. *Discharge by agreement.*

A contract not performed on either side may be discharged

1. By mutual agreement of the parties, the consideration being mutual release.

2. By a change in its terms or the substitution of a new contract.

3. By a new and independent contract with terms inconsistent with the old contract.

4. By release under seal or upon a sufficient consideration.

5. By a change in the parties, whereby a new party is substituted for the previous one by agreement of all three, while the terms remain the same.

II. *Discharge by contract provisions.*—A contract may be discharged by certain contract provisions where it is specified

1. That the non-fulfillment of certain specified terms shall give to one party the option of cancelling the contract.

2. That the fulfillment of certain conditions or the occurrence of certain events shall release the parties from further liabilities.

3. That the contract may be terminated upon certain terms at the option of either of the parties.

III. *Discharge by performance.*—A contract may be discharged by performance in accordance with its terms.

A modification of the terms of performance may be accepted in satisfaction of the performance as specified, and be equally effectual in the discharge of the contract.

The promisor is discharged from liability on his promise when he has made proper offer of performance and the offer has not been accepted.

IV. *Impossibility of performance.*—Where there is an express contract to do a certain thing possible both in nature and by law, the promisor must do it or pay damages, even though in consequence of unforeseen causes over which he has no control the performance of his contract has become impossible.

Exceptions.—The following cases are exceptions to the above rule:

1. Where a specified thing whose continued existence is essential to the performance is destroyed without default of the promisor.

2. Where the contract is for personal service and performance becomes impossible by reason of death, insanity or sickness.

3. Where performance becomes impossible by change of law or by some action under the authority of the government.

When a party has an option to perform his contract in either of two ways, if one of them becomes impossible, he is bound to perform it in the other.

V. *Discharge by operation of law.*

1. *Merger*.—The acceptance of a higher security for a lower between the same parties and upon the same debt as a contract under seal for a parol contract, will extinguish the lower by merger.

2. *Alteration*.—The intentional alteration of a material part of a written contract, by or with the assent of one party thereto without the consent of the other, will discharge all of the executory obligations of the former against the latter.

3. *Bankruptcy*.—Under a bankrupt law, a proper discharge in bankruptcy will, subject to the limitation imposed by law, release the bankrupt from all liabilities.

VI. *Discharge by breach of contract*.—Upon the breach of a contract, the injured party acquires a right of action for damage. The compensation for damages at common law is limited to pecuniary damages. In certain cases when such remedy would be inadequate, a court of equity will assume jurisdiction and enforce specific performance of the contract.

If one party to a contract breaks it in any of the following ways, the other party may avoid the further performance on his part, and bring action for damages:

1. By repudiation of the contract.

2. By an act that renders the performance impossible.

3. By a failure to perform such acts as may be precedent to the performance of the other party.

4. By failure to perform in a matter specified as essential to the continuance of the contract.

VII. *Discharge by right of action*.—When a right of action arises from a breach of contract such right of action and consequently the contract itself may be discharged by

1. A release.

2. An accord and satisfaction.

3. The judgment of a court of competent jurisdiction.

4. Limitation.

1. *Release*.—A valid release of the right of action must be either under seal or for a valuable consideration.

2. *Accord and satisfaction*.

A. Where there is an offer to accept the performance of something new in lieu of a claim, and the performance is completed before the withdrawal of the offer.

B. Where it clearly appears that a promise (not the performance) of something new is by agreement taken in satisfaction of a claim.

C. Where a cause of action is pursued to final judgment in a court of competent jurisdiction, a judgment in favor of the plaintiff discharges the cause of action by way of a merger, and a judgment against him on the merits discharges it by way of estoppel.

3. *Judgment of the court*.—When an action on a contract is brought in a court of competent jurisdiction, a judgment discharges the cause of action by merger if in favor of the plaintiff and by estoppel if in favor of the defendant.

4. *Lapse of time*.—In many states there are statutes called Statutes of Limitation, which fix a limit of time within which the right of action must be exercised, and which afford when involved an absolute bar to an action brought beyond the prescribed time.

LITERATURE

The Laws of Contracts—John C. Wait (John Wiley & Sons).

Engineering and Architectural Jurisprudence, Laws of Construction—John C. Wait (John Wiley & Sons).

Miller on Contracts—H. E. Miller (The Keefe-Davidson Co.).

The Law of Contracts—Alexander Haring (The Myron C. Clark Pub. Co.).

Clark on Contracts—Wm. L. Clark, Jr. (West Publishing Co.).

The General Principles of the American Law of Contracts—R. M. Benjamin (The Bowen-Merrill Co.).

The Principles of the English Law of Contracts—Sir W. R. Anson (Callaghan & Co.).

Cases on the Law of Contracts—W. A. Keener, 2 Vols. (Baker Voorhis & Company).

Contracts in Engineering—J. I. Tucker (McGraw-Hill Book Co.).

Engineering Contracts and Specifications—J. B. Johnson (McGraw-Hill Book Co.).

Bishop on Contracts—J. P. Bishop (T. H. Flood Co.).

Lectures on Law of Contracts—J. M. Brown, Washington, D. C. (Published by author).

Government Contracts—C. F. Carusi (Callaghan & Co.).

Laws of Business—Theophilus Parsons (The S. S. Scranton Co.).

Manual of Commercial Law—Edward W. Spencer (The Bobbs-Merrill Co.).

Business Law—Thomas R. White (Silver, Burdett & Company).

CHAPTER X

DAY LABOR AND CONTRACT SYSTEMS OF CONSTRUCTION

§ 110. **Business Methods.**—Two systems may be employed in the construction of public and private works.

First: The day labor system, in which an organization consisting of superintendents, foremen, mechanics and laborers is employed and the material purchased by the municipality or owner and the work is undertaken independently of contractors.

Second: The contract system by which men or firms who make a business of construction are employed under some form of contract to undertake the work.

Each of these systems has its advantages and disadvantages. Each may be entirely satisfactory under certain conditions and very unsatisfactory under other conditions. The choice of system must depend on the selection of the lesser of two evils when all conditions are considered. From the point of view of the parties having the work done the choice will be made of the system which will secure the lowest cost of construction, the best workmanship, promptness of construction and the elimination of contingences to the greatest degree.

It is important for the owner that the actual cost of the work should be closely known in order that he may determine whether the work can be financed and whether its construction will be warranted by the results that will be obtained from the investment.

The contractor is equally interested in the cost in order that he may definitely know that he can complete the work for a given sum and with a certain profit. Both owner and contractor are interested in a definite knowledge of all of the conditions involved in order that it may be possible to closely estimate what that actual cost will be. The owner often assumes that he can eliminate uncertainty by inducing the contractor to assume all responsibilities, take the risk of all uncertainties and undertake the construction at a fixed sum. This can be and is frequently done, but for such service as well as for all other services, payment must be made, and the prices paid for work performed under such conditions is usually excessive.

When the nature of the work is such that its character and extent can be accurately defined and when plans and specifications for such work are so prepared that they are clear and complete, the uncertainties are largely removed and contracts let to responsible and experienced contractors are usually satisfactory. When, however, the conditions are indefinite and indeterminate, as they may be in hazardous and novel construction because of incomplete investigation of conditions or from imperfect and indefinite plans and specifications, any estimate made must be more or less uncertain and will involve a serious risk. Such conditions must result either in exorbitant prices or the assumption of serious risks at a low price by contractors, who, under such conditions are apt to be more or less inexperienced and irresponsible. In the latter case, especially if the risk assumed by the contractor is realized to his detriment, there is a strong tendency for him to endeavor to recoup his possible losses by furnishing and doing as little as he can under his contract. This often results in disagreements and litigation and quite likely in poor work and general dissatisfaction.

In the fixed sum contract the interests of the owner and contractor are, in the main, directly opposed. The owner's desires are as previously outlined. The contractor's interest lies between a desire for a maximum profit and to establish or maintain a reputation for honesty, efficiency and ability. The latter desire will induce the responsible contractor to carry out his contract even at a loss but is insufficient for such purpose with an irresponsible man.

The day-labor system seems to offer a way of avoiding the difficulties of securing proper work under the contract system. Here, however, the owner exchanges the uncertainty of the honesty, ability and experience of the contractor for similar uncertainties in regard to an organization which he may have to establish for the special work at hand. In many cases he may find the evils he has assumed are as great as or greater than those which he has elected to avoid.

The problem then is to choose such business methods of construction as will avoid these difficulties so far as practicable. The answer is not apparent and indeed cannot be always the same, for the difficulties in various undertakings are so different that they must be met in each case in a different way and as the circumstances seem to warrant.

§ III. **Uncertainties in the Cost of Work.**—Difficulties, to be eliminated, must first be recognized, and one of the greatest difficulties in the way of securing the construction of work at reasonable cost lies

in the uncertainties as to what that cost may be. These uncertainties arise from various factors which are here briefly outlined.

A. The Engineer.—To the owner who proposes to undertake the construction of a plant or other piece of work, the uncertainty involved in the selection of an engineer is not the least of his troubles nor an unimportant factor in the expense of his undertaking. Much depends upon the honesty, integrity, judgment and ability of the engineer. For the best results, he must be a man who will make the interests of his client his own interests so far as equity will permit; his honesty and integrity must be beyond question; his judgment must be developed by knowledge and experience; he must have the ability to design economically and supervise intelligently the construction proposed; he must have sufficient self-knowledge to recognize his own strength and his own weakness, and sufficient character to subdue his personal pride and to demand and secure adequate advice on the subjects on which such advice is needed. An engineer with all such attributes is seldom available and such qualifications can only be approximated. No formulas can be offered for his successful selection. Careful inquiry among those who have had similar work performed, and observation of the ability developed by men in similar work, are the best bases for such selection.

An engineer may be highly successful in one field and a serious failure in some other which is radically different. It lies within every young engineer to develop these attributes of success to a greater or less degree; much will depend upon his individual will-power to make himself available for responsible service.

To the contractor, the engineer is an equally important element of uncertainty, especially where local conditions are unknown, plans and specifications are incomplete, and the contract places large discretionary powers in the hands of the engineer. Is the engineer honest, experienced and competent? Is he inexperienced, arbitrary and unfair? Will he shoulder his own mistakes or cover his errors, so far as possible, at the contractor's expense? The answers to these questions would remove one of the greatest uncertainties in the cost of work to the contractor; but unless the contractor has had previous experience under the same engineer, these questions can be answered only by experience.

B. Local Conditions.—Complete information covering local conditions, full and complete specifications, a fair contract and provisions for the arbitration of disputed questions will remove much of the uncer-

tainty. These can be removed to a greater or less extent by thorough investigation which should be undertaken by technical experts employed by the owner. The results of the investigation should be made available to those who undertake the construction, who should also be required to make such additional examination and investigations as will give them a personal knowledge of the conditions involved, so far as practicable.

C. Plans.—Complete and definite plans can be based only on a complete and definite knowledge of the local conditions. They must be indefinite to the extent that the knowledge of the conditions are indefinite. Complete, definite and proper plans can be prepared only by those who have sufficient knowledge and experience. Indefinite plans are frequently the result of indefinite information as to what should be required.

D. Specifications.—Specifications, like plans, are dependent upon both a knowledge of conditions and a knowledge of how the conditions should be met in order to secure the results desired. Their proper preparation is further complicated by the difficulty of so expressing the meaning and intent of the writer that they will clearly convey the same to the reader, and by the fact that their meaning may have to be interpreted under conditions which were not foreseen.

E. Contingencies.—Even when a fairly thorough preliminary investigation has been made, and where complete and definite plans and specifications have been prepared, contingencies cannot be eliminated although they will have been reduced. No reasonable investigation can be so complete that it will disclose all conditions that may develop during construction. If some contingencies become of minor importance on account of well defined local conditions, other contingencies may arise. Weather conditions may prove unpropitious and cause increased expense. Continuous rains may set in and delay work and cause more or less damage. Severe cold weather may reduce output and require protection in the performance of the work. Floods may come and cause great damage, and even tornadoes or heavy winds have added to the toll of extra expense which could not be foreseen.

F. Casualties.—Construction work is frequently accompanied by casualties more or less serious. These can be greatly reduced by care and watchfulness, but mankind will never become sufficiently reliable to eliminate them altogether. On construction work, every man is dependent for his safety on his fellow men, who are more or less careless and unreliable, and on tools, machinery and apparatus that are

liable to contain unknown and serious defects. The results are injuries or death, and damages and destruction, all of which add to the expense involved.

G. Transportation.—Almost every structure is dependent on transportation to some extent for its prompt construction and cost. This will probably be satisfactory but may cause trouble. The possibilities of freight blockades, misshipments, wrecks and various disasters add to the uncertainty and expense.

H. Equipment.—The satisfactory completion of construction depends upon promptly securing the proper equipment for construction purposes as well as the necessary equipment for the project to be constructed, both of which involve more or less uncertainties because others than the principals to the construction are involved. Manufacturers may have other orders that have precedence or may be unable to secure the materials necessary for making the equipment, and many other causes make this an item of extra expense.

I. Material.—To secure material when needed and at a reasonable price is often a serious difficulty. Both items must be ascertained as a basis for a cost estimate, but as an order can seldom be placed at the time the estimate is made, both delivery and cost may change before construction is possible.

J. Supervision.—It is exceedingly difficult to secure suitable supervision for construction work. Firms having an extensive business usually keep a number of dependable men on whom, from their previous experience, they can reasonably rely. Even such firms cannot keep all of the superintendents, foremen, etc., that they need when business is at its best; and they must depend on their ability to select and secure suitable men for temporary positions. The problem becomes more difficult and uncertain when an entire force is to be organized for the purpose of a single construction.

Letters and recommendations may assist in the selection of such men, but there is no way by which actual fitness can be determined except by trial, and repeated trials are often necessary. A superintendent or foreman who is inexperienced or unsuited to a certain position, may and frequently does add greatly to the expense of the construction.

K. Labor.—Skilled and unskilled labor is one of the important variables in the cost of construction. The ability to secure suitable men in sufficient numbers for the prompt completion of construction will greatly reduce cost. When men are in great demand they are hard to secure, the force employed becomes inadequate and not only is

the work delayed and the cost of supervision increased, but the men themselves become less efficient. When jobs are scarce and hard to find, the men on the work are attentive and efficient; but with plenty of work and labor in demand, they become independent and inefficient. The price of labor advances and the amount performed per individual becomes less. These changes frequently occur after an estimate is made and must be considered as serious uncertainties in all estimates.

L. Combinations.—Illegal combinations are among the uncertainties that will cause extra expense in construction. Combinations of contractors, material men and manufacturers are not unknown, and often seriously affect prices. They can seldom be proved, but they are often no less real. They can often be recognized only by a very definite knowledge of actual values, and their effects on cost can sometimes be obviated only by the rejection of offers and refusal to proceed until such condition can be eliminated.

M. Graft.—The form of dishonesty known as "graft" is more common to public than to private work, because the opportunities in public work are greater. It results from private combinations of dishonest men who have some influence which can be used to secure the acceptance of unfair prices or unfair work, and a consequent dishonest profit which may be divided among them. No high grade contractors or engineers, worthy of the name, ever enter into such dealings, and while this disreputable defect in business relations is still occasionally encountered and still needs watchful attention, it is believed to be less common than is popularly supposed.

N. Politics.—This evil creates some of the most important uncertainties in the cost of construction of public works. It sometimes results in forms of graft which have been previously mentioned but it often takes forms which, while objectionable, hardly justify so severe a title.

Political influences are commonly exercised to secure appointments of superintendents, foremen and inspectors who are unqualified for the work, and labor that is inefficient or incapacitated. They may be exercised to reduce hours of labor and to unduly increase the compensation paid. The reasons behind this may sometimes be laudable, as for example, the desire to improve labor conditions, the desire to afford work to the unemployed; or may be unscrupulous when exercised for personal influence. In any event, politics is one of the serious uncertainties which must be considered in the cost of public works.

To the above might be added legal complications, and perhaps other factors which are only indirectly covered in the above analysis.

Enough has been said, however, to fairly present the difficulties in the case. Were all of these factors present in every piece of construction, the chances of making estimates that would be reasonably close to the actual costs which could be secured by any method of construction, would be very remote.

§ 112. **Force Account Construction.**—The construction of engineering work by force account independently of contractors, eliminates certain difficulties involved in work let under a contract, but introduces other difficulties often no less serious. The responsibility for the construction and for the cost of the work is placed on such organizations as the owner or municipality may create for the purpose, and the result depends largely on the efficiency of such an organization. Where the work is continuous there is no valid reason, except the local conditions, why such an organization may not be established on a business basis and accomplish results which are fairly comparative with the results which can be accomplished by work done under contract. The possibility of creating an efficient organization is, therefore, the principal point to be considered.

In public organizations there is always the danger that there may be interference in the personnel of the organization and in its activities which will seriously handicap and injuriously affect its efficiency. In such organizations, especially in public work, there is not the personal responsibility for accomplishing proper work at the lowest first cost that obtains in works let by contract. There is no personal incentive to keep the construction cost at the lowest price in order that there shall be no personal losses and a maximum of personal gain. Frequently this lack of responsibility is felt in common by all engaged on the work, from the laborer to the highest authority. Excessive cost is commonly excused on the basis of supposedly better and more satisfactory construction.

The advantages and disadvantages of force account as applied to public works are analyzed by the author as follows:

Day-Labor or Force-Account System for Public Work.

ADVANTAGES.

1. Employment of local labor.
2. Saves contractor's profit.

DISADVANTAGES.

1. Politics, higher wages for labor, shorter hours and less efficient labor.
2. Usually entails greater actual cost of construction.

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|---|--|
| 3. Eliminates scamping and inefficiency of contractor. | 3. Introduces inefficiency of superintendents and foremen due to lower wages and political influences in appointments. |
| 4. Eliminates difficulty of drawing contracts for complex construction. | 4. Difficulties more fancied than real and can be overcome by employing efficient and experienced engineers. |
| 5. Permits flexibility and ease of modifying plans. | 5. Leads to careless investigation and design and unsafe estimates. |
| 6. Saving in cost of inspection. | 6. No real saving possible, inspectors are necessary to prevent carelessness by foremen. |
| | 7. Difficulty of fixing responsibility. |
| | 8. Tendency to maintain organizations when not needed. |

Under favorable circumstances and for certain purposes the advantages may offset the disadvantages, but such conditions are limited.

Mr. H. P. Eddy, who investigated the efficiency of certain city departments of Boston for the Boston Finance Commission, presented a paper before the Boston Society of Engineers which gave much pertinent information on this subject.

In order to determine the general practice of cities in doing work on extension of water pipes and sewerage systems by day labor or by contract, the following information was obtained: Of fifty-eight cities reported concerning the methods used for water pipe extension one-third were doing work by contract, but outside of New England forty-eight per cent were doing the work by contract. Of seventy-three replies in regard to methods used for sewer construction fifty-two were doing work wholly by contract, but outside of New England forty-eight of fifty-one cities reporting were doing work by contract. In Massachusetts seventeen out of eighteen reporting were doing work by day labor. While recognizing the abuses in the contract system, Mr. Eddy, nevertheless favored that system on account of the greater abuses in the day-labor system. In work done by day labor he found a strong tendency through political influences to employ older and less efficient labor, to increase wages above the comparative wages paid by contractors, to shorten hours, to pay wages for Saturday half holidays, general holidays and during sick leave, and by such means to greatly increase the cost of construction. In a comparison of eight comparable pipe sewers laid in Boston by day

labor and by contract he found the additional cost of work done by day to be from 48 per cent. to 220 per cent. of the cost of similar work done under contract. Similar figures and conclusions can be drawn from various sources, and while, in some cases, evidence is available to the contrary, such cases are believed to be the exception and not the rule.

Where the manager of work done by force account is directly responsible to an owner who gives personal attention to the expenditures involved, the objections enumerated above become less valid and better results can commonly be secured. When, however, an organization is effected for the purpose of a single construction, the management is confronted with the difficulties of securing suitable, experienced and efficient supervision. The best superintendents and foremen are commonly permanently engaged with contractors who have a permanent and continuous business, and men so employed do not care to break such connections for a position which can be at the best only temporary, and which may leave them at the close of the job without permanent connection. This factor is so important that in order to secure good men it is usually necessary to pay excessive salaries. The manager is at the further disadvantage of having no personal and intimate knowledge of the capacity and reliability of the men he must employ, and he must frequently secure them only to find that they are unsuitable for his purpose and are available only because their idiosyncrasies have made them unsatisfactory for permanent connections.

Another serious handicap is the necessity of purchasing an entire construction plant and tools for a particular job, which at its close can be sold only at a considerable sacrifice. Even the purchase of such equipment requires extensive experience and knowledge of the particular contract involved.

The engineer, or whoever must undertake the responsibility of carrying out work of construction on this system, should fully appreciate his responsibility and the probable effect of any failure on his client's welfare and on his own reputation and future prospects. Such work should only be attempted by those who have had actual and extensive experience, and have a detailed knowledge of men, equipment, and business methods which are not commonly acquired with an engineering education.

§ 113. **Contract at a Fixed Price.**—The oldest and most common method of letting work under contract is by receiving competitive bids of fixed prices. These may be either lump sums or unit prices

on each of a number of items which together constitute the entire work.

Contracting on a basis of either a lump sum or of unit prices is subject to the objection that the interests of the contractor and of the owner become at once antagonistic. It is the owner's purpose to secure the best quality of work and material at the prices paid, while the natural purpose of the contractor is to do the work as cheaply as possible and to economize both in the character of material and expense of labor, so far as the conditions permit.

If the contractor is a man of character, experience and reputation, and if his proposal has been based on definite and clear plans and specifications, his agreed price will contain a sufficient profit to assure the execution of the work in a satisfactory manner. If, however, he is unreliable, inexperienced and places the desire for profit above reputation, he may take the work at such a price as to assure a loss if he fulfills his contract. In this event, or possibly in any case, the letting of construction work to such a man will involve constant trouble, and usually poor ultimate results. Work let under contract should, so far as possible, be let only to men of experience and standing.

In any but the simplest forms of work that can be clearly and definitely planned and specified, unit prices rather than a lump sum should be required. The letting of work for a lump sum may lead to exorbitant payments for any extra work required. Where a lump sum is bid and a change in the work is made, a supplementary contract must be drawn and a readjustment made in the price to be paid. In such cases the contractor has a distinct advantage, for his compensation is fixed and his own price must usually prevail for any extra work involved. The lump sum contract gives no information as to what the contractor regards as a fair price for each item of the work he is to perform, on which information the deductions for work omitted and the extra payments for work performed might be based. While new work under a contract may be done on the basis of force account, such a method under contract conditions is usually unsatisfactory. The labor will usually be inefficient. When the laborer knows he is working for the company, the state or the city, his incentive to do his best is gone, for all lost time simply adds to the profit of his employer. For this and other reasons, force account work under contracts should be avoided wherever possible, and it can be largely avoided by the use of the unit price system of bidding, which can be used for extra work arising out of the change of plans. Force account also means added

work for the engineering department and careful supervision to see that the pay roll is not padded.

Notwithstanding its disadvantages, the fixed price system of contracting has been found the most practicable method for general conditions. It is based on the same principles as other similar business transactions and therefore appeals to the majority of business men. It also has some additional advantages to the owner in that while the actual cost may be high, a definite limit is fixed, the cost is known before the work is begun, and if the price is too high the work need not be undertaken.

When business men undertake to construct a plant or to erect a building, they naturally proceed in the same manner that they would follow in other business undertakings. They commonly neglect to consider the fact that they are beginning an undertaking of which they are ignorant and are depending on a personal advisor and his ability to design, supervise, and secure adequate construction. In such cases, invitations to bid are usually confined to responsible contractors, but an endeavor is made to let the work at the lowest practicable price in order that they may secure the most for their money, as in other business transactions. With complete plans and specifications, properly and clearly prepared, the results are fairly satisfactory.

When for any reason the price bid is too low to cover the cost of the work, the problem of securing proper construction at an unfair price arises. Many contractors under such circumstances will face the loss, and complete the work in first class and satisfactory manner; but it is equally true that there are many others who will take every advantage possible in order to effect a saving. When the work is of a well known character and the services to be rendered are thoroughly defined, a lump sum contract is unobjectionable; but as soon as serious elements of hazard enter the undertaking, such a contract becomes uncertain and must either be taken at an exorbitant figure or at a great risk of loss. Under such conditions, either the force account system or some other form of contract becomes desirable.

§ 114. **Excessive Waste in Competitive Bidding.**—The expense to contractors in estimating on work which they do not secure, results in a great economic waste from competitive bidding as it is now conducted. The Illinois Chapter of the American Institute of Architects in 1907 gathered statistics from five representative contractors who made competitive bids for buildings, costing from \$100,000 to \$150,000. From these statistics it appears that the average number of contracts

estimated by each builder was seventy-two, and the average number of contracts taken, ten. The average expense of each estimate to the general contractor was \$125 and in addition the expense incurred by subcontractors and material men was \$378, making a total of \$503 spent on each estimate by the contractor, subcontractors and material men. In addition to this expense, the head of each firm spent an average of twenty-one per cent. of the total time given the office business on these estimates. The average number of general contractors estimating on each building was approximately six, making a total cost of \$3,018 on each building or from two to three per cent. of the cost of the building.

Taking the total number of estimates made for the five contractors and deducting one-third for subcontractors' estimates used in common by the general contractors, leaves approximately \$120,000 as the total cost for estimates made on all work by these five firms. As the five contractors secured a total of fifty contracts, the expense of the bids from which work was secured was \$25,150 and the expense incurred for estimating contracts which were not secured was \$95,000, which amount was a dead loss to the five contractors, subcontractors and material men in one year. This loss must be met indirectly, in the long run by the owners of the buildings erected.

The committee in making this investigation estimated that in 1906, \$63,000,000 in building work was done in the city of Chicago and that the expense of estimating was at least \$1,260,000, of which \$1,000,000 was fruitlessly spent on unsuccessful estimates.

The committee suggested that this expense might be curtailed by employing a professional estimator to make a complete estimate of all labors, materials and expenses involved in a proposed building. This estimator should be paid by the owner and should be absolutely independent. The committee expressed the opinion that the nature of the estimator's position would enable him to secure low prices for the great mass of material by eliminating middlemen's profits and reducing opportunities for combinations. It was suggested that the owner should go over the plans and specifications of the building and the estimator's report of the cost of construction, and if he found the cost satisfactory, he should turn the papers over to a contractor satisfactory to himself and his architect. If the contractor was also satisfied with the amount of the estimate, he could be given the contract for the estimated amount, plus a fixed fee, depending upon the character and magnitude of the structure. At the completion of the work, if the building

costs less than the estimate, the committee suggests that the amount should be divided equally between the contractor and the owner; while if the cost ran above the estimate, the loss should be equally divided. They believe that in this way the interests of the owner and of the contractor could be made the same, and that their relations would therefore be harmonious instead of antagonistic. The difficulty in making such arrangements would probably be due largely to the lack of acquaintance between business men and contractors and to the fact that, as few men put up more than one or two buildings, they would naturally see greater economy in competitive bidding than in awarding the contract without competition.

The suggestion is, however, worthy of careful consideration, as some system of preventing unnecessary expense is desirable and all practicable economies will result both in reduced cost of construction and greater profits.

§ 115. **Contracts for Cost Plus a Percentage.**—To obviate the difficulties of the fixed price contract, various methods have been suggested and tried with results more or less satisfactory. The most common method has been to pay the contractor the actual cost of the construction work with a specified percentage thereof as compensation for his overhead expenses, personal services, and profits.

The advantages claimed for this system are that, as the risk or hazard of construction is entirely removed from the contractor, the owner can secure his services with the advantages of his skill and experience for the lowest practicable amount. While the owner is obliged, in this case, to assume the hazards or contingencies of construction, he will pay only such costs as are actually incurred and for which he should equitably pay.

There is no doubt but that the removal of hazard is an important factor in low bidding. Any successful man must charge prices which are sufficient to cover not only the actual cost which can be intelligently estimated, but also those contingent expenses which cannot be accurately foreseen, but which, nevertheless, will surely occur. Tenders from responsible contractors for work at a fixed price are bound, therefore, to be high enough to cover reasonable and possibly unreasonable conditions.

The percentage basis for the letting of contracts is, however, open to objections. One important objection is the fact that every increase in cost increases the amount payable to the contractor. Increased cost, while a detriment to the owner, is a direct financial benefit to the con-

tractor. Not all contractors are strong enough morally to withstand the resulting temptation.

Another serious drawback to all forms of contracting for cost plus a certain definite or variable return to the contractor is due to the inefficiency of management which is likely to result where a contractor's profit does not depend on his ability to do work economically. Where he has little or no financial interest in the actual economy of construction, the personal care in the choice of men and equipment and the close supervision which obtains under fixed sum contracts are often missing, with more or less unsatisfactory consequences.

Experience shows that it is almost or quite impossible to secure efficient working conditions under the cost plus percentage arrangement. The foremen and laborers, appreciating the fact that the contractor to whom they are directly responsible is not dependent on their greatest efforts for his returns, will almost uniformly reduce their efforts, with a resulting increase in cost and perhaps a detriment to the quality of work.

While the lump sum price assures personal responsibility, the contractor will not attempt work unless he feels confident that he can properly equip the same with suitable plant and supervision, as otherwise his chance for a profit would be small. In prosperous times, when the amount of work to be done is considerable, there is a strong temptation for the contractor, under the cost plus a percentage system, to take all work offered regardless of his ability to furnish suitable supervision and equipment. Such conditions are of course disastrous to low cost of construction and to satisfactory work. The use of the percentage form of contract should therefore necessarily be limited to firms with well established reputations, and must be confined to work for private companies not bound by the legal restrictions which govern public works. Under certain conditions such a plan is undoubtedly desirable. In extending the rapid transit system of New York City it became necessary to construct a third track on the Second, Third and Ninth Avenue elevated railway lines. The difficulties in the way of the extensive improvements required were serious, and it was necessary to effect the improvement with a minimum risk of danger and the least practicable interference with traffic on the elevated structure and on the streets below. The improvement aggregated about fifteen miles of such work requiring the fabrication and erection of about 50,000 tons of structural steel at an estimated cost of \$8,000,000. The Manhattan Elevated Railway Company decided to employ certain responsi-

ble contracting companies to do this work on the basis of cost plus fifteen per cent. This was made necessary on account of the intimate relation of the work to be done to the operation of the elevated railways and the safety and convenience of the public. It is evident that it would be extremely difficult, if not impossible, to have prepared a satisfactory contract and specifications in order to have arranged for a public letting, and quite impossible to have provided for safe and satisfactory operation and, at the same time, to have secured reasonable bids by the ordinary method of competitive bidding.

§ 116. **Contracts for Cost Plus a Fixed Sum.**—In recent years the objection to the cost plus a percentage form of contract has been somewhat reduced by changing the basis from a percentage to the cost plus a fixed sum. By this form of contract, the contractor cannot profit by any increase in cost, but on the other hand will secure the greatest returns to himself by the least expenditure of time and money for the owner. This plan eliminates certain objectionable features of the percentage form of contract but does not eliminate the inefficient methods and unsatisfactory labor conditions.

§ 117. **Contracts for Cost Plus a Variable Premium.**—Another form of contract has been used to some extent in the last ten years. Under this form of agreement, the contractor undertakes to complete the work for a fixed sum and in a definite time. In addition to this sum, he is to be paid a stated premium which is reduced or increased, accordingly as the actual cost and time of completion are greater or less than the stipulated costs and time of completion.

The advantage of this form of contract is that the owner can determine the final cost almost as closely as under the lump sum contract. If the cost of the work is less than the estimate, he is benefited to the extent of one half of the amount saved; while the other half is paid to the contractor as an extra premium earned. If the cost of the work increases above that of the estimate, half of the additional cost is paid by the owner and the other half is deducted from the contractor's premium. If the work is completed in advance of the fixed time, the contractor receives a certain agreed sum per day for the time saved; and if completed behind time, a corresponding deduction is made in the premium paid. The principal objection to this form of agreement arises from the possibility that the estimated cost may be high and the time of completion too great, under which condition the contractor may secure an unfair premium by his ability to reduce the cost and time below his estimates. If, however, this form of agreement is put

into competition with lump sum bids on the basis of the estimated cost and time provisions as has been proposed, an advantage may be secured by a reduced cost and by the unity of interests which should ensue from this form of agreement.

In a somewhat similar contract made in Boston, the agreement provided that the contractor should receive first the actual cost of the work plus ten per cent. of such cost. Upon the final completion of the work, the total cost plus the percentage was to be compared with the estimated cost made by the engineer, and provisions were made in the agreement, in case the estimate was unsatisfactory to the contractor, for a revised estimate by a board of three engineers. If the total cost of the work exceeded the estimated cost, then one fourth of this excess was deducted from the ten per cent. to be paid the contractor; and in case the work was less than the estimated cost, the contractor was entitled to receive one fourth of the amount saved. The entire cost of small tools and supplies used was charged to the work, and the cost of machinery, tools and appurtenances purchased for and used upon the work, less their value at the end of the contract, was also included in the computed cost.

There is no apparent reason why a contract under the above plans may not be satisfactory and may not be applied to the carrying out of public works under open competition. This could be done by contractors stating in their proposals the percentage they would accept in addition to the actual cost of the work, with proper provision for additions or deductions to be calculated on the basis above mentioned.

LITERATURE

How Quantity Competition can be Eliminated. Discusses advantages of eliminating the figuring of quantities by bidders, by H. M. Saumenig. Eng. Rec. Vol. 72, p. 566.

Some Objections to the Percentage Method of Bidding. Discusses objections to unbalanced bids. Staff Article. Eng. News, Vol. 50, p. 293.

Contracting on a Percentage or like basis. Advantages and disadvantages of lump sum and percentage bids. Staff Article. Eng. Rec. Vol. 54, p. 421.

Contract Methods of Doing Work. Discussion of advantages of definite specifications. Staff Article. Eng. Rec. Vol. 55, p. 479.

Competitive Contracts. Cost to bidders of estimating quantities. Staff Article. Eng. Rec. Vol. 58, p. 449.

Objections to Lump Sum Bidding. Staff Article. Eng. News Supplement, Nov. 12, 1903.

Municipal Contract System. Description and Advantages of Baltimore System of Contract Letting, by Mayor Thos. G. Hayes. Municipal Journal, Vol. 13, p. 106.

Contract with an Inducement for Economy. Describes Contract for Cost Plus variable bonus. Staff Article. Eng. News, Vol. 74, p. 468.

Cost Plus Premium Contracts. Advantages and disadvantages discussed. Staff Article. Eng. Rec. Vol. 55, p. 58.

Differences between Public and Private Contracts. Staff Article. Eng. News, Apr. 28, 1904.

Some Aspects of Force Account Construction. Staff Article. Eng. Rec. Vol. 60, p. 197.

Quantity Bids on Architectural and Engineering Contracts. Discussion of proper methods of making quantity estimates. Abstract of paper by G. A. Wright before the Technical Society of the Pacific Coast. Eng. Rec. Vol. 40, p. 535.

Different Plans of Letting Contracts. Discusses various systems, particularly Cost-plus-fixed-sum. Abstract of paper by Frank B. Gilbreth before American Public Water Works Ass'n. Eng. News, Vol. 56, p. 411.

Contract versus Day Labor. Discusses advantages of Force Account Method of doing work for city. E. W. Muenschler. Mich. Engrs. Annual 1898.

Relative Efficiency of the Day Labor and Contract System of Doing Municipal Work. Abstract of several discussions. Eng. News, Vol. 63, p. 503. See also Eng. News, Jan. 27, 1910.

Municipal Work by Day Labor and Contract. Abstract of discussion and results of investigations by Harrison P. Eddy. Eng. Rec. Vol. 61, p. 332.

CHAPTER XI

ENGINEERING AND ARCHITECTURAL WORKS CON- STRUCTED UNDER CONTRACT

§ 118. **Public and Private Works.**—By the term “public works” are meant works for municipalities, counties, states, and the nation, many features of which are controlled by law. By the term “private works” are meant works constructed by private parties, partnerships or corporations, such as private buildings, railroads, hydraulic plants, etc., which are not controlled by law so far as the form of contracts, character of specifications, and methods of letting contracts are concerned. The whole procedure of authorizing work, fixing contract requirements, advertising for proposals, receiving proposals, letting work, consummating contracts, and interpreting contracts differs materially in public work from that used in private work.

The laws governing the making and letting of contracts for public works have been framed to obviate collusion and fraud, and their requirements must be observed in order that a legal contract may be made.

Public works must usually be let only after advertising, and to the “lowest responsible bidder.” State laws sometimes require public work to be advertised for a certain length of time, in certain ways, and to a certain extent, previous to the letting of the contract. The legal or charter requirements for advertisements are imperative to secure the validity of the contract. Where the law provides that the contract shall be given “to the lowest responsible bidder giving adequate security,” such bid cannot be arbitrarily rejected. Any act whereby a higher bidder is made to appear the lowest, will invalidate the contract.¹

The contract to be valid must be executed without alteration in plans, specifications or time;² but when laws do not require contracts to be awarded to the lowest bidder, alteration may be made in contracts before they are executed.

Void contracts cannot be legalized by public officers but may be ratified by legislative action.³ Any reasonable requirements imposed

¹ Wait's Engineering and Architectural Jurisprudence, sec. 140.

² Ibid, secs. 141, 142.

³ Ibid, secs. 141, 142.

on bidders to secure or facilitate comparisons of bids lie within the discretion of the official letting the work, and such requirements must be observed.

When a certified check or other security is required with a bid for public work, and through error a mistake has been made, such security must be forfeited and public officials have no authority to waive such forfeiture. Determination of responsibility is discretionary but must be exercised in good faith. Acceptance by a public official may not, and usually does not, complete an agreement until such acceptance is formally ratified by the governing body.

In the preparation of the contract and specification, it is necessary to keep in mind the distinction between public and private works. Contracts and specifications for public work must be so drawn as to allow opportunity for intelligent competition.

Provision made for the performance of a payment for extra work are legal ⁴ if the work designated is actually extra work. If however the work designated is a material part of the work which it is known must be done payment so made will be illegal. In the case of *Moynahan v. Birkett*, the so called extra work was in reality an essential and known part of the work to be done and the court states: "When the law provides that the work must be let to the lowest responsible bidder, any clause in the contract which fixes the price for extra work without bids on that subject is illegal, and payments at rates specified may be enjoined at the suit of a taxpayer."⁵ In many cases the bid of contractors on their own plans may be illegal under similar circumstances, as public bodies are usually empowered to determine the *lowest* and not the best bid.⁶ In numerous cases however bids on alternate paving specifications have been declared legal,⁷ although such decision seems illogical and based on a misapprehension of the principles of competition.⁸

In the execution of public work, no departure from the contract requirements can be legally permitted, but the specifications must be

⁴ *Abells v. City of Syracuse* (N. Y.) 7 App. Div. 501. See also *Dillon on Municipal Corporations*, 5th Ed. Vol. 2, Sec. 801, p. 1199; also *Clark v. Pittsburg*, 217 Pa. St. 46, 51, and *Smith v. Chicago Sanitary District*, 108 Ill. App. 69, 78.

⁵ *Moynahan v. Birkett* (Sup. Ct. 2d Dept.), 31 N. Y. S. Rep. 293.

⁶ *Engineering News*, Vol. 74, p. 609; also 57 Wash. p. 649; 4 Neb. p. 160; and *Dillon's Municipal Corporation*, sec. 807.

⁷ *Eng. News*, Vol. 74, p. 1048.

⁸ *Ibid*, Vol. 74, Dec. 16, 1915.

rigidly enforced, even though such change might result in better work. The public is not bound by principles of justice and equity and is not interested in the contractor's success or failure, and any changes which are made to benefit or assist the contractor are apt to be misconstrued and criticised and may involve serious consequences to the engineer.

Private work, on the other hand, may be advertised or it may be let without advertisements, by public competition, by competition between selected parties or by agreement with a single contractor, as the owner or corporation may elect. In a private contract a verbal acceptance of a proposal may consummate the contract, and awards should therefore usually be made subject to the making of a written contract, if such written contract is desired.

In private work, other conditions and requirements are also radically different from those for public works; alternate bids, modifications of requirements, adjustments and betterments that conditions seem to require in carrying out the work in hand may be made whenever the parties to the contract agree. Rights may be waived, obligations cancelled, and extra compensation granted, whenever it appears that such actions are warranted by justice and equity or by expediency.

It is true that in public contracts, the legal requirements have been sometimes ignored or neglected, and no serious consequences have followed. Many such contracts which were invalid have been made and the works completed and paid for, even in some cases where there has been wilful neglect, dishonest intent and collusion and fraud. This has been due only to the fact that the question of validity has not been raised in court.

In other cases, honest errors, due to a mistaken conception of legal requirements, not well established by court decisions, have resulted in heavy losses and sometimes in financial failure to contractors who have honestly and conscientiously entered into otherwise fair and reasonable contracts for the performance of public works.

The risk of ignoring legal requirements is too great, and no contractor should enter into a public contract which is not clearly legal in every detail.

In the preparation of contracts for public works, it is therefore evident that the engineer is in equity bound to see that his designs and specifications are especially definite, full and complete, and as the requirements of the contract cannot be legally waived, especial precaution should be taken to see that they are fair and reasonable.

The contractor, on his part, should ascertain either personally or through attorney that all legal requirements have been complied with;

that the ordinance or order authorizing the work has been legally passed; that the work has been legally advertised; and that the contract and specifications fulfill all legal requirements. Ignorance of the law excuses no one, and in doing business with the public a knowledge of all requirements is assumed by the court and is neglected at the peril of the private citizen.

§ 119. **Negotiations for Construction Contracts.**—The negotiations which are necessary prior to the consummation of a construction contract will vary in kind and formality with the nature of the work to be done. Where the party letting the work is a private person or corporation, such negotiations may take any form desired. Usually the owner will invite bids based on specifications more or less complete, with or without some proposed contract form. The request for proposals may be advertised or notices may be sent to such parties as may seem available for the work in question.

The purpose of soliciting more than a single bid for either public or private works is to secure for the public or the owner the advantages of competition and the right to select a proposal which is advantageous. By such competition, contractors are induced to make close estimates, the amounts of which are usually dependent upon the amount of similar work available, and the state of the market for labor, materials, etc., to be furnished. Competitive lettings, if honorably carried out by all parties, are usually the most desirable methods of letting construction contracts. Where, in private work, the value of the work to be done, or the materials to be furnished, is well known, it may prove more satisfactory to let the work without competition to a responsible contractor known to do satisfactory work or to furnish the supplies, material or machinery especially desired, and at a mutually satisfactory price. Satisfactory results from private lettings are dependent on honorable dealings, and this method is perhaps open to greater opportunities for dishonesty when the work is let by a third party (the engineer or some other official), and not directly by the owner.

§ 120. **Dishonesty in Competitive Letting.**—The competitive letting of construction contracts is also open to dishonest practices. Contractors may combine with each other with the intention of securing high prices under apparent competition, where no such competition actually exists. Apparent competition has been sometimes secured by more than one bid by apparently different but actually the same parties. If the two bids submitted by the same party were both lower than those submitted by other bidders, the lower bid would be withdrawn on account of alleged mistakes, allowing the higher bid to stand and thus

securing the contract at a price greater than the lowest price at which the contractor was really willing to undertake the work. This withdrawal of a bid could be formerly accomplished on the common law right to withdraw or revoke an offer at any time before its acceptance. To prevent such withdrawal, bidders, especially on public works, are now usually required to accompany their proposals with certified checks or bidder's bonds, which they agree to forfeit if they revoke their proposal.

Where negotiations are carried out between private parties and responsible contractors, the requirement for a check or bond to accompany the bid is seldom made, as in such cases proposals are usually made in good faith and will be carried out if accepted.

Contractors also sometimes agree among themselves on the party to whom the award shall be made. The lowest bid, sometimes at an exorbitant price, and the contractor to submit it will be agreed upon, and other contractors will either withdraw or submit higher bids in order to simulate competition. Such combination can be prevented only by a knowledge of the real value of the proposed work. These combinations are illegal and, in case of public work, may in fact be criminal. If they can be proved, they will invalidate a contract so secured, whether public or private.

Occasionally competitive bids are invited only for the purpose of compelling a favorite bidder to reduce his bid to the lowest possible amount and with no intention of utilizing the bids so submitted, except as a means of forcing the favorite bidder to reduce his bid.

It is evidently unjust to request proposals from bidders whose bids will not actually be considered, and thus cause a needless expenditure from which they can receive no consequent possible benefit. Any engineer or business man pursuing such tactics will soon find himself in ill repute among responsible contractors and his future attempts at securing satisfactory bids greatly embarrassed. The engineer should know no friends nor favorites among the bidders in the letting of any work to be done under his specifications and should strive to award the contract to the lowest and best bidder in all cases.

§ 121. **Restricted Lettings.**—For private lettings, proposals may be restricted to those persons or companies known to be most reliable or capable, and others whose capacity or capabilities may be questionable may be excluded. Where the knowledge of those letting the work is sufficient to justify such discrimination, such a selection seems desirable, as it greatly simplifies the selection of a responsible contractor

and prevents a needless expenditure by those parties who might otherwise desire to make proposals which would, for the reason mentioned, receive no serious consideration. Ethically only such bidders should be included in the request for proposals as the owner is willing to consider in awarding the contract.

To secure proposals which are competitive, they should all be based upon plans and specifications which should be as specific and in as great detail as practicable, and all available information should be furnished to each bidder alike. Any additional information that will give the advantage to any favored contractor is an injustice which should be strenuously avoided; and when such information is furnished by an official, without the knowledge of the owner, such action is doubly dishonest and operates as an injustice not only to other contractors but also to the owner who under such conditions has not the real competition to which he is justly entitled. So far as practicable, the controlling factor of the letting should be the lowest bid. This can often be accomplished by making the specifications so complete and definite that other differences shall be obviated.

If any owner desires to confine his purchase to a single company, he should inform himself, either directly or through his engineer, by proper inquiry and investigation so that he may feel that he possesses the requisite knowledge of values to undertake negotiations with such company without putting others to needless expense.

§ 122. **Securing Low Bids.**—It is the reasonable desire of every engineer and owner to secure bids for the proposed work to be let under contract at as low a figure as can reasonably be made, and at the same time assure good material and good work. To accomplish this, the ideas of the parties who are asked to undertake such work must be understood and appreciated, and if requirements are made which are unnecessary and add to the expense or increase the hazard and consequent chance for extra expense, they should be eliminated. The wishes of the contractor in these matters should not be ignored but should be considered so far as practicable, for aside from the question of equity, there is the question of expense, which will always appeal to the owner.

Mr. Richard Morey, of the Morey-Faulhaber Construction Company, expressed his ideas on how to get low bids from good contractors, in a paper before the St. Louis Railway Club, as follows:

"1. Give full and detailed information as to the work, all dimensions, quantities, classes of materials; everything that can possibly be used to figure costs.

"2. Ask for bids on as many units as can be applied to the work. This may increase slightly the office work, but it will reduce costs. To use grading as a simple example, a contractor will bid lower and the work will cost the railway company less, if the proposals are made so as to separate bids on excavation hauled, excavation wasted, embankment borrowed, over-haul with a short free haul and all possible classifications of material. To the contractor this means that uncertainties are reduced to one or two items and that he will be paid for just what he does. To the railway company it means an elastic contract that readily covers the inevitable changes of line or plans, and that the company pays for just what it gets.

"3. Rewrite some of the clauses in the contracts and specifications, particularly those which applied to former conditions, but do not fully cover present ones, and, especially, some of them which have grown from inter-lineations made from year to year in your printed forms.

"4. Recognize the relation between the responsibility of the contractor and the requirements for the bond and the retained percentage. At the time the contract is signed, and the responsibility of the contractor is measured by the full amount of the contract, the railway company is satisfied with a bond; later, as the work is near completion and parts of it even in use, the railway company still has the bond and also the retained percentage and the contractor's responsibility has become insignificant.

"5. Give us as inspectors men whose knowledge of the work at least approaches that of our foremen.

"6. Give us our full quantities on our monthly estimates and then see to it that the vouchers made to cover those estimates move promptly through the auditor's office to the treasurer."⁹

§ 123. **Suggestions of American Society of Engineering Contractors.**—A committee of this society submitted a report in January, 1913, in which the following desirable requirements for public contracts were expressed:

"1. The committee thinks it impossible to submit a complete form to cover all phases of all engineering contracts, but a work of much value can be done by adopting some general principles and formulating them so that they may be made a part of substantially every contract.

"2. Every condition, of whatsoever character, by which the parties are to be bound should be submitted to bidders as part of the specifications on which they bid. The contract to be signed should be annexed to the specifications. In this way the bidder is not liable to be surprised by new conditions appearing in the contract submitted for his signature after his bid has been made and accepted.

"3. The greatest vice of contracts is uncertainty. In adopting any form of contract or specifications every effort should be made to secure exactness of definition of the rights and duties of both parties.

⁹ From the "Proceedings of the St. Louis Railway Club."

"4. Recognizing the impossibility of foreseeing every emergency, some authority must be devised for the determination of either unexpected physical conditions or unforeseen ambiguities in the contract.

"5. The first requisite to this is promptness, so that the work may proceed. This doubtless requires that all disputed questions shall be primarily settled by the engineer present on the work.

"6. While the engineer is the best-fitted person to reach a prompt decision, his relation to the owner unfits him for an impartial decision. There must, therefore, be some provision for an appeal to an impartial tribunal and final settlement of all disputes by it.

"7. Disputes should, as far as possible, be settled as the contract progresses, so that the parties can know how they stand. To this end all matters of dispute should be reduced promptly to writing and all appeals from the engineer's decisions should be promptly taken.

"8. Each party should assume full responsibility for his own share of the contract.

"9. This involves the assumption, by the owner, of responsibility for the local conditions and for the borings or other explorations of the site. The contractor should bid on guaranteed local conditions, with an increase or reduction of price for variations from these. The locality belongs to the owner, and the contractor should not be obliged to gamble on it.

"10. The principle also requires that a contract should not both provide the exact details of construction and guarantee the result. If the contractor is to do the work according to exact plans furnished him by the owner, the owner should take the responsibility for the result. If the contractor guarantees the result, he should be free to adopt his own methods of construction.

"11. The contractor, especially when bound by a time limit, should be given the utmost freedom as to the order and manner of doing the prescribed work.

"12. Definite provision should be made for the assertion, in writing, of demands made by either party varying from the normal contract price. The contractor should give prompt notice of a claim for extras and the owner of a claim for a decrease or for the assessment of damages.

"13. Some rule should be prescribed for the owner's protection in case of delay on the contractor's part, either by a right to annul the contract or to take over the work, in whole or in part, or to deduct actual or liquidated damages. The subject is one of great difficulty and needs most careful consideration.

"14. The contractor should be protected from loss by delay of the owner or the owner's other contractors, and provision made for settling such losses without suit where possible.

"15. What is the proper amount of retained percentages? What should be the maximum part of the contract price to be retained until final payment? Differences of opinion should be adjusted and a uniform rule adopted.

"16. Material men insist that the contract bond should provide for payment for materials and labor. This leads to greater security to the material men and consequently lower prices. But it is an unnecessary cost to contractors of established credit. This subject needs the views of both sides.

"17. Some contractors and engineers maintain that the contract conditions should be as brief as possible. Your committee believes that all subjects which experience has shown may produce conflict should be definitely disposed of by the provisions fixed in the contract, even if this extends its length.

"18. After every effort has been made to avoid all uncertainty in the contract and to settle all disputes as they arise, some honest differences of opinion as to the rights of the parties may persist to the end of the contract. The final settlement of uncontested matters should be made without prejudice to the right of the contractor to recover disputed claims in the courts. It has, unfortunately, become too common to declare that on final payment the contractor shall sign a release of all claims arising out of the contract. This is a one-sided and dishonest provision. When payment is earned by a fulfillment of the contract, it ought not to be denied because the contractor believes that he is entitled to more, nor should he be forced by necessity to waive access to the courts to correct wrongs done him in the course of his contract."

The report further referred to various forms of contract drawn by definite authorities, including the Royal Institute of British Architects and the American Institute of Architects, commending these forms in many respects, but added:

"One general remark may be made in regard to nearly all such forms—that they have been generally prepared by persons representing owners, such as architects and engineers, and that, however fair their intention, the inevitable tendency has been to protect the owner's rights at the cost of the contractor's."

§ 124. **Further Suggestions.**—In 1904 various engineers, manufacturers, contractors and material men, met in Gulfport, Mississippi, to organize the American Public Works Association, and among other things adopted the following as the basis which in their opinion should underlie the making of public contracts:

"1. When state or municipal statutes conflict with association rules the latter shall be waived.

"2. When work is done on a percentage basis, security should be given to guarantee estimate and faithful performance of the work.

"3. Designing engineer shall not compete for work advertised to be let under his plans and specifications.

"4. No bids shall be asked until money to pay for the work has been provided.

"5. Bids shall be opened and read in public.

"6. No bids shall be submitted after time named in advertisement.

- "7. No bids shall be withdrawn after time set for opening of bids.
- "8. Illegibility, or ambiguity, shall invalidate a bid.
- "9. Bidders shall not be permitted to change prices stated in bid.
- "10. Bids shall state specifically, make of apparatus or machinery proposed, and same shall be specified in contract.
- "11. When all bids are rejected new bids shall not be made on the same specifications without readvertising.
- "12. The amount of certified check required shall be stated in advertisement calling for bids.
- "13. Bid bonds may be substituted for certified checks.
- "14. Checks or bid bonds shall be returned to all but successful bidder as soon as award of contract is made.
- "15. Award of contract shall be made within thirty days after bids have been opened or checks returned to bidders.
- "16. Bond shall not exceed 25 per cent of contract price.
- "17. Twenty days shall be allowed contractor in which to furnish a satisfactory bond.
- "18. In event of discrepancies between the drawings and specifications decision of the engineer shall be final.
- "19. All instructions regarding work shall be given by the engineer or his assistants.
- "20. Extra work shall only be done on written order of engineer when authorized by contractee at a price to be agreed upon.
- "21. In deducting material not required only the value of same shall be deducted.
- "22. Changes in construction shall not be made to lessen quantities of material in transit or in process of manufacture unless contractor be paid for all actual loss occasioned.
- "23. When a specific make of machinery or apparatus is specified in contract same shall be furnished in accordance with manufacturer's plans and specifications submitted with bid.
- "24. Engineer or his authorized assistants shall at all times have access to the work and materials for purpose of inspection, and have notice of concealed work before it is covered.
- "25. In event of emergency work contractor shall notify engineer and engineer shall furnish inspector.
- "26. Work done in regular progress of the contract and ordered torn down for purpose of inspection, if found to be in accordance with the specifications, shall be at the cost of contractee.
- "27. Engineer shall give written notice to contractor when work or material has been rejected.
- "28. Monthly estimate shall be made on or before the fifth day of each month.
- "29. Monthly estimate shall be based on the contract price and shall include all material delivered and labor performed.
- "30. Ten per cent of monthly estimate shall be retained by contractee until work is completed.

"31. Time shall be allowed contractor for delay caused by strikes, accidents or other causes beyond his control.

"32. When work is completed engineer shall accept or reject same within a reasonable time.

"33. Contractor is released from all future responsibility when contractee takes possession of plant, whether settlement has been made or not, unless otherwise agreed."

§ 125. **Rights of the Contractor.**—The suggestions made in the previous section, representing the point of view of the contractor in regard to the principles that should be observed in the preparation and in the letting of contracts for public works, should receive due consideration by engineers and others who are connected with such work. It would seem to all who are familiar with contracts for public works that much injustice is commonly imposed on contractors by the forms of contracts ordinarily prepared. It is often unconsciously assumed that the only one to be considered in the preparation of a contract is the public or owner, and that the engineer must guard their interest in every way, with just as little thought for the interests of the party of the second part, who must take up the real burden of practical construction, as is possible without driving contractors from the field.

These unjust covenants have been used so long in the making of contracts that they are copied, rewritten and strengthened, frequently without realization of the fundamental inequity involved, and with a strong conviction that they are essential to properly protect the public or the owners, and sometimes perhaps to show that the engineer or attorney has the welfare of his client properly conserved.

It is true that the party letting the work may word the contract as he will, and that any injustice he may desire to inflict, if within the law, may be included if contractors can be found to accept such a contract. Unjust provisions commonly and rightfully add to the cost of the work and the owner is often unduly taxed for unfair and unnecessary requirements inserted in the contract by the engineer or attorney, which add nothing to the owner's protection or to the value of the work.

While it is true that contractors may exercise their option as to whether or not they will submit bids at a public letting, it is also true that with large overhead expenses for equipment, plant and permanent staff, they are frequently, for financial reasons, practically forced to submit to arbitrary and unjust exactions rather than to remain idle. They are therefore not altogether free agents in these matters.

Honest contractors frequently complain that contractors as a class are regarded as dishonest and unscrupulous, especially by the young and inexperienced, and that unjust contracts are the result of this false conception. This is possibly true, and if so is unfortunate; but every experienced man, whether engineer or contractor, knows that there are men in every walk of life, in every business and in every profession who are bound only by their legal obligations and give little or no thought to ethical and moral obligations. There are unfortunately others who will go even further than this, and who will pursue dishonest and illegal methods of securing business advantages, even with the chances of serious legal punishment.

Connected with engineering and architectural works are not only the engineer and contractor, but the client, owner, inspector, the mechanic and laborer, and in public work, the politician and sometimes many undesirable characters who draw their living from the public purse.

All classes of men possess quite similar characteristics; some of every class possess honor, integrity, experience and ability, while others are dishonest, inexperienced and incompetent. Some are dependable, some tricky, and these characteristics are possessed in various degrees and are manifested in various ways. No business or profession has a monopoly on either the desirable or the undesirable traits, and the men who follow the profession of engineering and the business of contracting are no exception to the rule.

The men who contract for engineering and architectural works are, as a class, men of experience and ability whose close contact with the details of construction has given them usually a more exact and more definite knowledge of means and methods than that possessed by the engineer. As they usually devote their time to some particular line of work, they frequently become specialists whose services can be utilized to great advantage. There are also others, novices in the business, sometimes ignorant and uninformed, who desire to enter the contracting field, ready to assume any risk for the purpose of experience and possible profit.

The actions of men are not only modified by their experience and integrity, but their point of view is also frequently modified by conditions which play an important part in their action. The contractor who has secured and is carrying out a profitable contract may act in a very different manner when he has undertaken a losing contract. In the first case he may be generous, obliging and conscientious; in the latter

case, close, technical and perhaps more or less unjust and possibly unscrupulous. The desire to protect himself from losses more or less serious, may make an entire change in his feelings, actions, and point of view.

The engineer whose plans and specifications are well prepared and complete, who has fully covered all emergencies in the plans and contract provisions he has prepared, may be fair, just and considerate. If his plans or specifications are in error or incomplete and his reputation for ability is at stake, he may become unfair and unjust and may be willing to sacrifice others financially to protect himself and cover up his mistakes.

It is the common assumption in most contracts that the engineer is the arbiter who stands between the two parties to the contract, and will adjust fairly and equitably all disputes which may arise in the premises. This assumption may be made a legal obligation when agreed to by both parties, and will be maintained by the courts within rather wide limits if this function is exercised with reasonably good faith.

That the engineer is a disinterested party from whom perfect justice can be expected under all conditions is, to a considerable extent, a legal fiction. All men are prejudiced by their relations and consequent point of view, regardless of their personal inclination and desire to render substantial justice. No engineer employed by an owner, in constant communication with him and acting as his personal agent in dealings with the contractor, can have a perfectly unbiased view point in regard to the questions which arise and which he is required to arbitrate and decide, especially if such matters are largely discretionary and rest purely on judgment. Usually the very points to be decided are raised between the contractor and the engineer before his clients know that any difference actually exists, and the engineer is commonly too close to the work to always obtain a proper perspective concerning the questions at issue. The different points of view frequently give rise to perfectly honest differences in opinion between the engineer and contractor, and frequently involve unfriendly relations which color every question which may arise. The whole question becomes quite a different one if judgment and discussions are eliminated and the control of the engineer is confined to technical findings which are based on comprehensive plans and explicit contracts and are susceptible of only one interpretation.

With these conditions in view, it is folly to assume that dependence can be placed on the good faith of the parties to any considerable extent in the making of contracts. It is desirable in all business affairs to avoid relations with men who are lacking in ethical and moral principles, and especially those who are unquestionably dishonest in their dealings. The possession or lack of these qualities is seldom obvious, and it is quite impossible to avoid all business relations with all parties having objectionable tendencies. *Good faith and confidence should have little place in the preparation of a contract, but justice and equity should be its foundation.* Neither party to the contract should be compelled to depend on the good faith of the other or of the engineer to any greater degree than is absolutely necessary. This requires that the contract be clear, explicit, definite, exact, complete and fair, and that every doubtful question should be eliminated, so far as possible.

§ 126. **The Arbitration of Disputes.**—The engineer and architect must always exercise certain judicial functions in the interpretation of the covenants of a contract in order that the work may promptly proceed without needless delays for adjustment and litigation. These points, where these functions must be exercised should, however, be reduced to a minimum by the completeness of the plans and the definiteness of the specifications. Matters of engineering judgment must be left to the engineer. He is the proper person to determine whether the contractor has furnished proper material and has done proper work under the terms of the contract, and this judgment requires the exercise of technical knowledge, fairness and common sense. The necessity for the exercise of judicial functions in the legal sense of the term, should be eliminated as far as practicable. The engineer should be empowered to make decisions which will permit the expeditious completion of the work, but such decisions should be subject to appeal, to expert arbitration or to court review. Some advance toward this end has been made in England. The Council of the Institution of Municipal and County Engineers, at the request of The National Federation of Building Trades Employers of Great Britain, has recommended the use of the following clauses by the members:

“In case any dispute or difference shall arise between the Council, or the engineer on their behalf, and the contractor, either during the progress of the works or after the determination, abandonment, or breach of the contract,

“(1) As to the construction of the contract,

“(2) Or as to any matter or thing arising thereunder;

"[Except as to the matters referred to in the undermentioned clauses 'a to . . .', all of which shall be left to the sole discretion or decision of the engineer, viz.:—

"(a) As to the provision of everything necessary for the proper execution of the works, etc.

"(b) As to the amendment of errors arising from inaccurate setting out of works.

"(c) As to the quality of materials and workmanship.

"(d) As to the competency of the general foreman on the works.

"(e) As to the competency or conduct of any person employed on the works by the contractor.

"(f) As to the measurement and valuation of extra work and variations, or the mode of ascertaining the amount to be allowed for extra work and variations.

"(g) As to the rejection and removal of work and materials not in accordance with the specification or the instructions of the engineer, and the substitution of other work and materials therefor, and all other matters referred to in this clause.

"(h) As to defects or faults which may appear in the works after completion.

"(i) As to the opening of work for inspection.

"(j) As to the date when the works are completed.

"(k) As to the execution of works having been delayed by inclement weather and other causes.

"(l) As to the carrying on of the works with due diligence, etc., etc.

"(m) As to the expenditure of provisional sums.

"(n) As to the issuing of certificates relating to payments to the contractor.

"Also, except as to the matters referred to in the under-mentioned clauses numbered 'A to . . .', all which shall be left to the sole discretion or decision of the council:—

"(A) As to the assignment or sub-letting of any portion of the works.

"(B) As to the determination of the contract by the council."

"These are intended as illustrations of the matters which engineers may wish to deal with themselves, or may wish their councils to deal with, instead of allowing them to be submitted to arbitration. Each engineer can insert in this part of the clause whatever matter he desires to exclude from arbitration.

"(3) Or as to the withholding by the engineer of any certificate to which the contractor may claim to be entitled, either party shall forthwith give to the other written notice of such dispute or difference, and such dispute or difference shall be and is hereby referred to the arbitration and final decision of a person to be appointed, on the request of either party, by the president for the time being of the Institution of Municipal and County Engineers, and the award of such arbitration shall be final and binding upon the parties. Such reference, except of the question of certificate,

shall not be opened until after the completion, or alleged completion, of the works, unless with the written consent of the council, or the engineer, and the contractor. The arbitrator shall have power to open up, review, and revise any certificate, opinion, decision, requisition or notice, save in regard to the said matters in dispute which shall be submitted to him, and of which notice shall have been given as aforesaid, in the same manner as if no such certificate, opinion, decision, requisition or notice had been given. Upon every, or any such reference, the cost of and incidental to the reference and award respectively shall be in the discretion of the arbitrator, who may determine the amount thereof, or direct the same to be taxed as between solicitor and client, or as between party and party, and shall direct by whom and in what manner the same shall be borne and paid. This submission shall be deemed to be a submission to arbitration within the meaning of the Arbitration Act, 1899:

"Provided always that this clause shall not apply to any contract, the total original amount, sum, or value of which, exclusive of any extras or additions, is less than one thousand pounds or to any difference or disputes which in connection with any one contract shall involve a total amount, sum, or value of less than fifty pounds, in either of which two events all matters arising out of the contract and any difference or dispute shall be in the sole judgment and discretion of the engineer, whose decision shall be final and binding on all parties and without appeal." ¹⁰

§ 127. **Progress of Arbitration.**—The equity of including arbitration clauses in construction contracts is becoming more widely recognized each year. The American Institute of Architects has for a number of years suggested a form of contract which in its later form (1915) at least provides for arbitration of all matters in dispute. A covenant for the arbitration of disputes was embodied in a uniform building contract, adopted in 1911 by a committee representing the Chicago Architects' Business Association, the Western Society of Engineers, and several local associations of manufacturers and contractors in the building industry. This contract authorizes the architect to decide disputes between owners and contractors; but provides that if either party dissent from this decision the matter must be submitted to a board of arbitration, two of whom shall represent the owner and contractor, respectively, and the third to be selected and named in the contract.

The matter of including an arbitration clause in engineering contracts has received considerable discussion, and such clauses have been used in numerous cases. That this will be the general practice in the near future seems inevitable. Surely the engineering profession with

¹⁰ Engineering Record, July 27, 1912, Vol. 66, p. 100.

its generally well established reputation for honesty and fairness will soon recognize the justice of such a provision and will welcome its adoption. From the individual standpoint, the relief from determining disputes on matters on which a personal bias must be recognized by every fair minded man, should be welcome, for such a provision can in no way be regarded as a reflection on the honor or competency of the engineer.

LITERATURE

The Responsibility of the Engineering Profession for the Conduct of Public Contracts, by Major Cassius E. Gillette. Eng. News, Vol. 57, p. 587.

How to Draw Specifications which will Shut out Competition and Make Certain the Award of the Contract to a Favored Bidder. Eng. News, Vol. 54, p. 602.

A Proposed Law to Prevent Collusion and Graft in the Letting of Public Contracts. Abstract of paper before Am. Soc. Eng. Cont., by C. E. Gillette outlining proposed New Legislation in Philadelphia. Eng. News, Vol. 66, p. 744.

Combinations among Contractors. Discussion of legal and moral rights of contractors in combinations. Editorial Eng. News, Vol. 34, p. 345.

Loose Specifications and Dishonest Contracts. Editorial Eng. News, Vol. 60, p. 368.

Validity of Contracts Covering Alternative or Otherwise Uncertain Bids.

Discussion of legality of allowing alternative material in Specifications. Editorial Eng. Rec. Vol. 53, p. 467.

Fixing a Basis in advance for Comparison of Alternate Bids. Discussion of a plan to prevent charges of Corruption in calling for alternative bids. Eng. News, Vol. 70, p. 221.

A plan to Limit Unbalanced Bidding on City Contract Work. Discussion of plan devised by Dept. of Water Supply, New York. Eng. News, Vol. 69, p. 777.

Alternative Forms of Paving Contracts. Suggestions for specifications for asphalt paving. O. X. McLoughlin. Eng. Rec. Vol. 70, p. 476.

Contractor's Bids on their own Plans Declared Illegal. Cites Case in City of Seattle. Eng. News, Vol. 74, p. 609.

Alternate Specifications for Public Work are Legal. Cites several cases by D. T. Pierce. Eng. News, Vol. 74, p. 1048.

The Duties of Engineers in Enforcing Contracts, by A. J. Himes. Eng. News, Vol. 48, p. 45.

Arbitration, by Onward Bates. Discussion by different members. Jour. W. E. E. Vol. 17, p. 481.

Arbitration, Its place in our professional Practice. Paper before Tech. Soc. Pac. Coast, by G. A. Wright, Jour. Assoc. Eng. Soc. Nov. 1900. Also Const. News, June 29, 1901.

Should an Engineer be Vested with Judicial Functions. Discussion of subject. Editorial Eng. News, Supp. Vol. 51, p. 189.

Arbitration of Contract Disputes. Editorial. Eng. News, Vol. 68, p. 683.

Engineers as Arbiters of Public Equity and Justice. Address by W. M. Daniels of Interstate Commerce Comm. Eng. Rec. Vol. 70, p. 623.

Discretionary Clauses in Contracts. Cites objections to such clauses.

W. B. King Eng. Rec. Vol. 68, p. 308.

The Discretion of Government Engineers. Cites Cases of unfairness in enforcing contracts, by Wm. B. King. Eng. Rec. Vol. 65, p. 348.

Relation of the Contractor to the Public Official. Abstract paper to American Road Congress 1912, by C. A. Crane. Eng. News, Vol. 68, p. 712.

Business Methods in Construction Work. Abstract paper to Cleveland Engineering Society, by Jas. L. Stuart. Can. Eng. Vol. 25, p. 648.

Contract Troubles. Discussion of some legal points. Editorial. Eng. Rec. Vol. 46, p. 179.

A Plea for Contractors. Discussion of fairness in contracts, Paving and Municipal Engineering. Vol. 8, p. 225.

Planning in Contract Work. Discussion of the value of foresight. Eng. Rec. Vol. 71, p. 792.

Duty of the Engineer Toward Contractors. Discussion of fairness in writing and enforcing specifications. Editorial. Eng. News, Vol. 48, p. 287.

Joint Responsibility of Engineers and Contractors. Editorial. Eng. Rec. Vol. 54, p. 366.

Straight Talk for the Contractor. Notes on economics in contracting. Eng. Rec. Vol. 72, p. 124.

Problems of the Contractor. Abstract of address on contracting in reinforced concrete. L. C. Wason. Eng. Rec. Vol. 69, p. 23.

CHAPTER XII

ADVERTISING AND LETTING CONTRACT

§ 128. **Purpose of Advertisement.**—The preparation of the *advertisement* and the *instruction to bidders* presupposes that the preliminary work of preparing plans, contracts and specifications are essentially completed and that the work is ready to be let.

The purpose of the advertisement is to bring the proposed letting to the notice of manufacturers, contractors or others who may be interested in such work in order that suitable competition may be secured.

The medium for advertising should be selected with due regard to the persons whom it is desired to reach, although the manner and extent of advertising will always be controlled by legal requirements in the case of public contract.

In work where only local competition is desired, the local paper having the widest circulation among the particular class of contractors desired, should be selected. In works of any magnitude, especially when proposed for small cities, advertisements should be inserted in the engineering and contracting papers of the country, having wide circulation among the contractors whom it is desirable to reach.

On account of the expenses of advertising, an advertisement is usually confined to only such general information as will enable a contractor to determine whether or not he desires to undertake the work.

Engineers in charge of large works, either public or private, usually send copies of the advertisement directly to all responsible and desirable contractors in order that the letting may be brought directly and quickly to their attention. For public work a list of all contractors interested in the work to be let is usually kept on file and the advertisement is sent to all who have applied. In letting private work it is quite usual to omit the public advertising entirely and confine the notices to reliable contractors especially equipped with plant or experience for the work to be let. Such a procedure would be entirely illegal for public work, as the advertisement, the public letting and certain other formalities are legal provisions made and necessary to guard against fraud in public contracts.

§ 129. **Nature of Advertisement.**—The advertisement should clearly state what is to be done. It should explain where, when, by

whom and for what proposals are to be received. The advertisement is intended to call the attention of interested parties to the fact that certain work is to be let under contract, and should include such information concerning the extent and character of the work to be done as will allow them to judge whether they wish to examine further into the matter, with the intention of bidding on the same.

The advertisement should be clear and concise in its statements. The matter which it should contain will depend somewhat on the character and extent of the work and whether the bidders expected are local men or men from distant cities.

The advertisement should be published not only in the usual way, but should be printed on slips and attached to the specifications or be printed on the specifications, so that all who secure them will also secure a copy of the advertisement, as it should form a part of the completed papers. Bidders on work have certain moral and legal rights which are to an extent established by the advertisement.

The advertisement should not be published until the work has been duly authorized, the preliminary investigations made, the design, contract, and specifications completed, and the financial arrangements made, and the performance on the part of the owner or public assured. Municipalities and private parties have not been altogether scrupulous in conserving the rights of bidders. Sometimes advertisements have been issued which have caused contractors to go to considerable expense in their preparations for bidding, only to find after such expenses have been incurred, that the letting has been abandoned on account of unforeseen difficulties or failure to finance the project. In one such case twenty-six contractors were called from all parts of the United States to one of the states west of the Missouri for the purpose of bidding on a large municipal sewer contract. When they arrived they found that an election was to be held on the day that bids were to be received to determine whether or not the city should issue bonds for the proposed improvements. Bids were to be deposited by four o'clock and the result of the election could not be known until late in the evening. The bonds failed to carry by a vote of two to one. Even under these circumstances the mayor proposed to open bids "to see how the bids compared with the engineer's estimate." He was prevented only by strenuous objection on the part of a number of the contractors. Some of the contractors had come from points as distant as Washington, D. C., and the average expense was probably at least \$500. The municipality by its inconsiderate action, occasioned

a needless expense of about \$13,000 to the contractors who had been asked to bid on the work. Whether or not there was any legal recourse may be questioned, but the difficulties and expense involved in legal proceedings were so great that no attempt was made to secure legal redress. The moral iniquity involved in such a procedure needs no comment; it probably resulted more from thoughtlessness than from any vicious intent, but the result was the same. Such occurrences are not altogether unusual. The engineer in charge of the work is commonly blamed when such a condition results and he should endeavor to prevent their occurrence, both from his appreciation of fair play and for the sake of his reputation.

§ 130. **Analysis of Advertisement.**—On any work where bidders are expected to come from a considerable distance, the advertisement for proposals should contain the following information:

Outline of Advertisement

1. By whom bids will be received.
 2. Where received.
 3. When received.
 4. Nature of work or material to be furnished.
 5. Location of work.
 6. Amount of work or material to be furnished.
 7. When contract is to be begun and when finished.
 8. Where plans may be seen or obtained.
 9. Where specifications may be seen or obtained.
 10. What security will be required with proposal. (If resident bondsmen are required, it should be stated.)
 11. What bond will be required with contract. (If resident bondsmen are required, it should be stated.)
 12. When proposals will be opened.
 13. When contract will be awarded.
 14. Other information of interest or importance to nonresident bidders.
 15. From whom general information may be obtained.
 16. Reservation of rights to reject any or all bids, or to waive formalities.
 17. Official signatures of officers letting work or receiving bids.
- These matters will be discussed in detail under the heading *Instruction to Bidders* of which they are a part or to which they are usually appended.

§ 131. **Formalities.**—As previously noted various formalities in regard to the letting of contracts for public works have been made mandatory by legislation in order to assure, to as great an extent as possible, the elimination of fraud in such lettings. Advertising must be done to a certain extent and in a certain manner in order to assure a due knowledge of the proposed work to all who may be interested and sufficient time for the preparation of proposals. Proposals must be submitted and received only at a certain definite time, in order that no single bidder shall have undue advantage. These bids are either to be opened at once or are to remain sealed until opened and publicly read, in order that the bidders and the public may know the prices made by each contractor and the lowest bidder. It is usually provided, so far as practicable, that the work shall be let to the lowest bidder, although of necessity the questions of responsibility and experience must receive due consideration in order that the lowest and best bid may be determined.

Collusion between public officials and contractors is made possible by avoiding public advertising or by so limiting the time after the advertisement is published, that undesired competitors cannot submit intelligent and safe bids. It is also accomplished through inexact, indeterminate, unfair and arbitrary specifications containing numerous doubtful clauses that are left to the decision or discretion of the engineer. By such means the expense to a favored contractor may be greatly reduced while an unfavored contractor may be put to large expense. Hence the favored contractor, knowing he will get unfair protection, can safely make a low bid and secure the work. While indefinite specifications are frequently due to ignorance and are not always written with this end in view, their presence always gives an impression of either ignorance or dishonest interest, and they should be studiously avoided.

To avoid even the appearance of evil the engineer should arrange and conduct the letting of public work in a way that will eliminate as far as practicable all possibilities of unfairness or favoritism.

In private contracts, only such formalities as may seem desirable are adopted, but the elements of fairness are the same. Parties who will not be considered should not be permitted to bid and when any contractor or manufacturer is requested to submit a bid, he is entitled to fair treatment.

§ 132. **Time Allowed.**—Ample time should be allowed, from the time of advertising to the time at which proposals are to be received for the bidders to make necessary investigation on which to base

an intelligent proposal. The time necessary will depend on the accessibility of the work and on its character and extent. The bidders must have sufficient time to examine the necessary data and to secure information concerning prices of material and labor and to make such preliminary studies of the methods and plant needed in the construction, and for such financial arrangement, capital, bond, etc., as conditions may require. There is usually a tendency on the part of the officials of municipalities and private companies to unduly shorten the time allowed for these purposes, but the engineer must impress upon his client or employer the disadvantages of such a course. Unless ample time is given to determine all of the factors which will affect the cost of the proposed construction, the doubt and the uncertainties involved will increase the prices bid and the cost of the proposed work. Every uncertainty leads to the same result, and it is just as important to allow proper time for the examination by contractors as to provide plans and specifications which are clear and explicit.

§ 133. **Form of Proposal.**—The proposal may either be a printed form or it may be left for the bidder to make out in the form of a written communication. It will depend on the amount and character of the work as to which is preferable. When the work is simple and the bid is a "lump sum" for the entire work, a special form is not essential although even then it adds greatly to the facility with which bids may be examined and compared. When there are a number of items for which proposals are desired, a form for the proposal becomes essential in order to assure a fair comparison. Such a form properly prepared insures uniformity in the bids submitted so that they may be directly compared on the basis of price, as such forms are usually so made that the bidder has only to fill out the blanks left for prices in statements which have been framed by the engineer, and which correspond with the terms used in the specifications. All unaltered bids can hence be readily compared, and it is usually provided that such forms must be used unaltered and that changes, modifications or additions will cause the bid to be rejected. Where work is of a nature that such form is possible the question of price only remains to be decided, at least among bidders of equal responsibility. Under conditions where different machinery or supplies are to be furnished the difference in price bid does not furnish such an obvious means of comparison, as quality and detail become important, and these, together with experience, responsibility and prices bid, must be considered and

a decision reached which must depend on the judgment of the officials letting the work.

The blank form of proposal is sometimes bound with the specifications and is sometimes a separate instrument. In the latter case it should refer to the specifications as filed at the place mentioned in the advertisement.

Certain declarations that

(a) "The bidder has carefully examined the location, plans and specifications," and

(b) "The bid has been made without collusion or fraud," are commonly embodied in the form of proposal. They have little legal significance, but serve only as a warning.

Clauses covering the following matters should also be included:

(c) The agreed date of beginning and completion.

(d) Stating the character and amount of security submitted with the bid and agreeing to forfeit the same if the bid is accepted and the bidder fails to enter the contract as agreed.

(e) An agreement to furnish security and a statement as to the character of the same.

(f) The names of subcontractors, when parts of the work are to be sublet to other contractors or manufacturers, and finally

(g) The signature of principals, their place of business and the signature of witnesses or an acknowledgment if required.

The following examples will show the usual features of these forms.

Example A.

PROPOSAL

TO THE BOARD OF PARK COMMISSIONERS OF THE CITY OF BOSTON FOR
BUILDING ABUTMENTS AND WING-WALLS FOR A BRIDGE AT WOOD
ISLAND PARK, EAST BOSTON.

The undersigned hereby declare that —he ha— carefully examined the annexed form of contract and specifications, and will provide all necessary machinery, tools, apparatus, and other means for construction, and do all the work, and furnish all the materials called for by said contract and specifications in the manner prescribed by the contract and the specifications, and the requirements under them of the Engineer, for the sum of
..... (\$.....).

Accompanying this proposal is a certified check for the sum of one thousand dollars, as called for in the foregoing advertisement.

No member of the City Council, and no person in any office or employment of the City of Boston, is directly or indirectly interested in this pro-

posal, or in any contract which may be made under it, or in expected profits to arise therefrom; and this proposal is made in good faith, without collusion or connection with any other person bidding for the same work.

Name _____
Address _____

Example B.

PROPOSAL

Made by _____, residing in _____, (date) _____.
_____ do hereby declare that _____, the only person interested in this proposal, and that no other person than the person— herein named, has any interest in this proposal, or in the contract proposed to be taken; that it is made without any connection with any other person or persons making proposals for the same work, and that it is in all respects fair and without collusion or fraud.

And _____ further declare that _____ have carefully examined the proposed location of said work, and the annexed specification and form of contract, and the plans now on file in the City Engineer's office, and that _____ will contract to do the work and furnish the material called for by the annexed notice to Contractors, and the annexed contract and specifications in the manner and on the conditions required, upon the following terms:

			Price Bid Per Lineal Foot
In	From	To	
1. Oak Street	Watch Fac'y Sewer.....	Main Street ....	.....
2. Main Street	Oak Street	Grove Street ...	.....
3. Grove Street	Main Street	First Street ....	.....
4. Grove Street	First Street	Second Street ..	.....
5. Grove Street	Second Street	Third Street ...	.....
6. Grove Street	Third Street	Fourth Street ..	.....
7. Grove Street	Fourth Street	Kishwaukee St..	.....
8. Main Street	Grove Street, South	End of Lateral..	.....
9. First Street	Grove Street, North	End of Lateral..	.....
10. First Street	Grove Street, South	End of Lateral..	.....
11. Second Street	Grove Street, North	End of Lateral..	.....
12. Second Street	Grove Street, South	End of Lateral..	.....
13. Third Street	Grove Street, North	End of Lateral..	.....
14. Third Street	Grove Street, South	End of Lateral..	.....
15. Fourth Street	Grove Street, North	Oak Street .....	.....
16. Fourth Street	Grove Street, South	End of Lateral..	.....
17. Oak Street	Fourth Street	End of Lateral..	.....
18. Kishwaukee Street..	Grove Street, North	End of Lateral..	.....
19. Kishwaukee Street..	Grove Street, South	End of Lateral..	.....

Extra	Price Bid
For each Y connection on 12-inch sewer.....	
For each Y connection on 10-inch sewer.....	
For each Y connection on 8-inch sewer.....	
For each Equalizer	
For each Lamphole	
For each Catchbasin	
For each Manhole	

The prices named above are to include the cost of doing all other work required by the specifications or appertaining thereto.

The undersigned agree to begin work within thirty days after signing a contract and to complete the required work within six months thereafter. — submit a certification for \$3,500, which — agree— to forfeit should the work be awarded to —, in accordance with the plans and specifications and should — fail or refuse to enter into the contract with security as specified. The undersigned propose to furnish the ——— Surety Company as bondsmen. The sewer pipe and specials to be furnished under this contract will be those manufactured by the ——— of ———, ———.

Respectfully submitted,

Name

Address

§ 134. Instructions to Bidders.—The instructions to bidders, supplement the advertisement and should contain the directions for the preparation of proposals and prescribe such formalities as may be required in their presentation. The instructions will vary in their requirements with the degree of formality with which it is desirable to conduct the letting. The more complete the plans and the more definite the specifications, the more rigid can the instructions to bidders be made with security to all parties. It is sometimes necessary to receive bids on items such as machines, supplies, etc., where it is undesirable or impossible to furnish specifications in detail. In such cases, the instructions cannot be as formal as when specifications are complete. The instructions should be as complete as necessary for each particular case, and should explicitly state everything required for the submission of a formal proposal. Clearness in these instructions will save much explanation and consequent loss of time. Too great formality should be avoided in any case.

“Instructions to Bidders” still further establishes the legal and moral rights of those bidding on the work.

If the advertisement is not made a part of the forms, the instructions to bidders should include all matter included in the advertisement.

The instructions are usually arranged in about the following order:

- A. General notice, including time of receiving bids and general character of the work.
- B. How sealed, and to whom delivered
- C. Formalities required in proposals.
- D. Manner of stating prices.
- E. Estimates.
- F. Where information can be obtained.
- G. Reservation to alter amounts of work.
- H. Reservation as to amount of work let under single contract.
- I. Reservations as to time of beginning and completion.
- J. Reasons for rejection of bids.
- K. Security to be required with bid and with contract.
- L. Security with contract.
- M. Miscellaneous requirements.

§ 135. Details of Instructions.

A. General Notice—Receiving Bids, etc.

(a) "Sealed bids for the work above named, endorsed with the title and also with the name of the person or persons making the same, will be received at the office of until at o'clock .. M., at which time the bids will be opened by the and publicly read, after which the contract will be awarded."

For the last clause in the above, one of the following is sometimes substituted:

(b) "After which the bids will be referred to the engineer (or other officer) for recommendations."

(c) "The contract will probably be let at the regular (or special) meeting of the on at o'clock .. M."

(d) "After which the bids will be considered and the award made as early as practicable."

B. Proposals—How Sealed and to Whom Delivered.

(a) "Proposals must be inclosed in a sealed envelope and addressed to, and further indorsed with the title"

(b) "Each bid must be inclosed in a sealed envelope, and delivered to the; and in the presence of the person offering the bid, it will be deposited in a sealed box provided for that purpose."

C. Formalities Required in Proposals.

(a) "N. B. Bidders are warned that all bids which are deficient in either of the following requirements may be rejected as informal." (Formalities adopted are here added.)

(b) "No bids will be received if detached from the package in which it is bound; nor must any of the accompanying papers be detached therefrom, but the entire package must be unbroken and in good order when the bid is deposited."

(c) The bids must conform to the printed forms, in order that a fair comparison may be made of all. Any deviation from said forms by omission of prices, or the insertion of written additions by the bidders, will invalidate the bid. Such addition will ensure the rejection of the bids. All bids must be full in every particular."

(d) "The bids must be made upon blanks furnished by the or their authorized engineers."

(e) "No change will be made in the form of the bids nor must any additional modifications or any form of specification be annexed."

(f) "Each bidder must sign the plans upon which his bid is based, in the office of the city engineer, and the date of such signing must precede the date of opening the bids."

(g) "When a firm is a bidder the member of the firm who signs the firm name to the proposal should state, in addition, the name of all individuals composing the firm."

(h) "Each bidder is required to state in his proposal his name and place of residence; the names of all parties interested with him; and if no other person be so interested, he shall distinctly state the fact; also that it is made without connection with any other person making any proposal for the above work; and that it is in all respects fair, and without collusion or fraud."

(i) "If any bidder wishes to withdraw his proposal he may do so before the time fixed for the opening, by mentioning his purpose to, and when his proposal is reached, it will be returned unread."

(j) "Permission will not be given for the withdrawal of any proposal."

D. Manner of Stating Prices.

(a) "The prices must be written in the bid and also stated in figures; and all proposals will be considered as informal which are not in conformity with this notice."

(b) "Bidders will state the proposed price for each separate item of the work, by which the bids will be compared. These prices are to cover all the expenses incidental to the completion of the work, in full conformity with the specifications."

(c) "These prices are to cover all the expenses of furnishing material other than that specified to be furnished by the city, and all tools and labor, in completing the work aforesaid in conformity to the contract and specifications prepared by the same."

E. Estimate.

(a) "The engineer's estimate of work and material by which the bids will be compared is as follows:" [The estimated quantities of material to be used and work to be done should follow here.]

F. Where Information Can Be Obtained.

(a) "Bidders must get their information as to the local conditions of trade, labor, character of the soil, probable amount of ground water, rock, etc., from personal inquiry upon the ground. Such data will not be given at this office except that the records as to any sub-construction, etc., of which it has knowledge, will be freely shown."

(b) "On account of the character of the work, the above mentioned quantities cannot be estimated in advance, with accuracy; therefore bidders are required to submit their bids upon the following expressed conditions which shall apply to and become a part of every bid, viz.: That bidders have satisfied themselves by personal examination of the location of the proposed work and by such other means as they may elect, as to the accuracy of the foregoing estimate of the engineer; and that they will not, at any time after the submission of the bid, dispute or complain of such statements of the engineer; nor assert that there was any misunderstanding in regard to the nature, or amount of the work to be done."

G. Reservations of Rights to Alter Amount of Work, etc.

(a) "The right is reserved to increase or diminish in quantity as may be necessary in the judgment of the the variation from the estimate, however, not to exceed ten per cent."

H. Reservations as to Amount of Work Let in One Contract.

(a) "The reserves the right to let the work as a whole or in parts. Contractors will state in their bids the least and greatest amounts of work for which their bids are made."

(b) "Bids will be considered for the entire work only."

I. Reservation as to Time of Beginning and Completion.

(a) "Work must be begun on or before (or days after the completion of the contract) and must be completed by (or days after work is commenced.)"

(b) "Bidders must state the length of time in which they will agree to do the work and such time will be regarded as a consideration in awarding the work and will be made an essential part of the contract with a proper forfeiture (or with a forfeiture of dollars per day) attached for its non-fulfillment."

(c) "The time allowed to complete the whole work will be days, as provided in the specifications."

J. Rejection of Bids.

(a) "Reasonable grounds for supposing that any bidder is interested in more than one bid will cause the rejection of all bids in which he is interested."

(b) "The right is reserved to reject any or all bids, and to waive any informality in the bids received; also to disregard the bid of any failing bidder or contractor, known as such."

(c) "The bidder must satisfy of his ability to perform the work for which he bids."

(d) "The fact of any person or firm being in arrears to the city of on debt or contract or in default as surety or otherwise upon any obligation to the city, or who has failed in previous contracts to comply with the requirements or specifications of said contract, shall be deemed a sufficient cause for the rejection of his or their bid."

K. Security with Bid.

Normally a proposal is an offer that can be withdrawn or cancelled by formal notice at any time before formal acceptance. In order to assure absence of fraud and the opportunity for the comparison of proposals, and to reserve the privilege of deliberation and the acceptance of the contract when duly awarded, a certified check or bond for a specified amount is frequently required with proposals as a guarantee of good faith that if the contract is awarded to the bidder he will enter into a formal contract for the performance of the obligation for which the bid was made.

In order to assure the validity of a forfeiture, on the refusal of the bidder to enter into the contract in accordance with his proposal

after an award to him, it is desirable to require him to make a specific statement in the proposal that in case the award is made to him and he fails to enter the contract within a specified time, he shall forfeit the amount deposited (as a certified check or bond) as liquidated damages for such failure. If the instructions simply require a check for a stated amount to accompany the bid, such deposit may be regarded as a penalty which can be retained only to the extent of the actual damages sustained and proved in a court of law.²

Such deposits may be required by law, and even when not so required are a reasonable requirement which may be imposed if desired by the parties letting the work. Such requirement is especially desirable when work is advertised and the contractors who bid may or may not be responsible.

To make such a forfeiture legally valid, the acceptance of the offer must be identical with the offer and no conditions more burdensome than those on which the offer was based can be imposed. In the negotiations of a private company with selected responsible contractors or manufacturers for a contract for work, material or machinery, and especially where the letting is informal, such a deposit is not usually considered necessary and is seldom required.

In fixing the amount of security required with the proposal, due consideration should be given not to impose undue hardships on bidders.³ Sometimes the amount necessary is fixed by law as a given percentage of the total amount of the proposed contract. Sometimes such security is tied up for a long period, pending final award; and if the amount is large, it may seriously tie up the capital or resources of the bidders who may have a number of such proposals out at one time. From the bidders standpoint, a "bid bond" from a security company is more satisfactory. In general, however, the certified check is more satisfactory to the owner as in case of forfeiture it is more readily collectable without litigation than a bond.

(a) "Security to the amount of \$. will be required with each proposal."

(b) "A certified check for \$. shall accompany each bid as a guarantee that the bidder if successful, will enter into contract for the construction of the work, which if he refuses to do, will be forfeited to the city as liquidated damages, on account of such refusal."

² See Wait, Eng. & Arch. Jurisprudence, sec. 168, and Wait, Laws and Contracts, secs. 92-97.

³ See Eng. News, Vol. 52, p. 152.

(c) "Each bid or estimate shall be accompanied by a certified check payable to or by the signing in writing, of two freeholders of the city of with their respective places of business or residence, to the effect that if the contract be awarded to the person making the estimate, they will upon its being so awarded become bound as sureties for its faithful performance, and that if he should omit or refuse to execute the same, within days after notice that such contract has been awarded to him, they will pay the corporation any difference between the sum to which he would be entitled upon its completion, and that which the corporation might be obliged to pay to the person to whom the contract may be awarded at any subsequent letting; the amount in each case to be calculated upon the estimated amount of the work by which the bids are compared. The signing above mentioned shall be accompanied by an oath or confirmation in writing of each of the persons signing the same that he is a freeholder in the city of and is worth the amount the security required for the completion of the contract and stated in the proposal, over and above all his debts of every nature; that he has offered himself as surety in good faith, and with the intention to execute the bond required by law, if the contract shall be awarded to the person or persons for whom he signs to become surety. The adequacy and sufficiency of the security offered, shall be approved by the mayor of the city of after the award is made and prior to the signing of the contract."

L. Security with Contract.

(a) "Security satisfactory to the mayor of the city of and equal to one-half the contract price will be required with the contract."

(b) "The person or persons to whom the contract or contracts may be awarded, will be required to attend at this office, with the sureties offered by him or them, and execute the contract within days from the date of award; and in case of the failure or neglect so to do, he or they will be considered as having abandoned it, and is in default to the city of; and thereupon the work will be readvertised and relet, and so on until the contract be accepted and executed."

M. Miscellaneous Requirements.

Other points to which the attention of the contractor is sometimes called are:

(a) "The attention of bidders is called to the specifications and form of the contract under which the work is to be done; and also to the requirements in regard to security."

(b) "Bidders are informed that no deviation from these specifications will be allowed, unless written permission shall have been obtained signed by"

(c) "A copy of the advertisement, these instructions and the specifications will be attached to the contract, and will form a part thereof."

(d) "Plans can be seen, and specifications and form of the contract can be obtained, at the office of, of the city of"

N. Plans and Specifications.

A copy of the pamphlet containing instructions to bidders, form of proposals, form of contract, general conditions, general and detailed specifications and contract drawings will be furnished upon the receipt of a deposit of, which deposit will be returned to the bidder upon the return of the said pamphlet and contract drawings, in good condition within days after bids are opened.

O. Qualifications of Bidders.

No bid will be received from parties who are not regularly engaged in the kind of work to be let. The character and experience of the bidder will receive full and detailed consideration and he must be able to show a financial standing which will warrant the award of contract to him. Otherwise his proposal will not be considered.

(a) "Bidders must accompany their proposal with samples of the material proposed to be used; which samples shall be retained by the city and all materials furnished by the contractors shall be equal to the sample furnished."

(b) "Bidders will state brands of material proposed and the make of other material which they intend to use in the work for which bids are proposed."

(c) "Other things being equal, preference will be given to local labor and material."

(d) "Bidders are invited to be present at the opening of the bids."

(e) "The right is reserved to reject any or all bids or to ignore any irresponsible bidder known to be such."

§ 136. **Receiving and Opening Bids.**—In public lettings, bids should be received up to a given hour, and any bids which are offered after that hour should be rigidly excluded. Such a provision may at first seem arbitrary and unnecessary, but bids are sometimes delayed for fraudulent purposes. If an extension of five minutes is allowed,

why not an hour, during which time other bids might be opened and the figures furnished to the late bidder? An absolute and definite time requirement seems, therefore, essential.

Bids should be sealed and should have the name and address of the bidder on the envelope in order that they may be returned unopened if such necessity should arise. In cases where many contracts are being let or when proposals are being received for a number of separate contracts, the title of the work for which the proposal is submitted should also be endorsed on the face of the envelope, in order that the bids may be sorted and arranged.

The bids should be immediately opened and publicly read in the presence of the bidders and others interested. If held for even a few hours before opening, there is always a possibility of fraud. This possibility is reduced to a minimum when they are immediately opened and immediately read in public.

If time is essential to tabulate the bids, then the time of opening the bids should be made early enough to permit of such tabulation before the meeting of the legislative body who are to make a final award.

§ 137. **Letting the Work.**—In the letting of work, various considerations may influence those who have the matter in charge. The lowest and best bid should always be selected. In many cases the right decision is obvious, but the question may arise as to what constitutes the *best* bid. Differences in opinion may honestly arise from difference of experience, concerning men, methods and the weight to be given to various factors. Familiarity with a particular contractor may impress the individual favorably or unfavorably as the case may be, and fortunate or unfortunate experience with a certain material or machine may create an unfair judgment concerning the same, when it is compared with another similar material or machine, which the actual conditions do not warrant. Personal prejudice is an important factor in judgment which the engineer should endeavor to eliminate from his own decisions.

The following factors, with the exception of items "C" and "D," may be legitimate influences in the letting of a contract.¹ Factor "C" is evidently corrupt while "D" is due to personal prejudice:
In General.

A. Price.

B. Experience and Responsibility.

¹ Suggestion taken with alterations from Power, Feb., 1905, p. 112.

C. Politics.

Graft.

Friendship.

Reciprocity.

In selecting materials, supplies, etc., the following factors also enter:

D. Fashion.

E. Appearance.

Symmetry.

Finish.

In selecting machinery the following may also apply:

F. Reputation.

Of Manufacturer.

Financial.

Dependability.

For Efficiency.

As a machine.

Capacity.

Safety.

Simplicity.

Regulation.

Design.

Accessibility.

Adjustability.

Materials.

Dimensions.

Accessories.

Workmanship.

G. Delivery.

Promised.

Distance of shipment.

LITERATURE

Bids for Municipal Works. Discussion of value of published bid prices. Editorial. Eng. Rec. Vol. 49, p. 406.

The Right to Withdraw Erroneous Bids. Account of Court ruling allowing withdrawal. Eng. News, Vol. 37, April 30, 1898.

The Award of a Contract for Public Work to a High Bidder. Court authorized City of New York to award contract to best bidder. Eng. Rec. Vol. 54, p. 37.

Awarding Public Contracts to High Bidders. Account of Court ruling that award to high bidder was illegal. Eng. Rec. Vol. 54, p. 419.

The Rejection of all Bids for Public Work. Objections to this procedure. Editorial. Eng. Rec. Vol. 58, p. 29.

The Requirements and Theory of the Advertisement or Notice to Bidders on Contracts for Public Works, by Jerome Cochran. Eng. News, Vol. 66, p. 306.

Instructions to Bidders on Contracts, by Jerome Cochran. Eng. News, March 7, 1912, pp. 434 and 453.

Security for Contracts. Desirability of retained payments. Editorial. Eng. Rec. Vol. 55, p. 315.

Surety Bonds of Three Classes, Bid on Proposal, Contract and Maintenance Bonds. Discussion of the bonds and fairness in contracts, by Fair Dodd. Eng. World, Vol. 4, p. 401.

Concerning Contractors Surety Bonds. Discussion of failure of surety company's bonds to serve purpose by A. H. Markwart. Eng. News, Vol. 71, p. 1035.

Contractors and Sureties. Recent decisions by U. S. Supreme Court and obligations that must be assumed in case of stoppage work, by Geo. A. King. Eng. Rec. Vol. 70, p. 50.

Low Bidder Forfeits Surety. Account of court ruling at Cleveland, Ohio. Eng. Rec. Vol. 70, p. 219.

CHAPTER XIII

CONTRACTS

§ 138. **Ordinary Business Transactions.**—Almost all business transactions involve contracts, either actual or implied. The majority of minor business transactions are so definite and so quickly executed that no written memoranda are either necessary or desirable.

A calls B, a coal merchant, by telephone and inquires the price of hard coal. B replies \$9 per ton. A asks to have ten tons delivered. B delivers the coal; A sends a check for \$90. The transaction is complete; an oral express contract has been entered into and performed; no writing was necessary.

§ 139. **Necessity of Written Agreements.**—When, however, the transactions become at all complicated, and where much time will elapse prior to or before final performance, the details of the agreement may become indistinct or uncertain in the minds of one or both of the parties, unless the same are reduced to writing.

While an express contract may be either oral or written, it is highly desirable that if it is not to be immediately performed and completed, it should be made in writing in order that a record of the transactions shall be made both as a memorandum for the information of the parties themselves, or for their administrators in case of death. This is especially desirable whenever the agreement is of moment, and especially where it is at all complicated by general or technical specifications of any kind that may possibly be misunderstood, overlooked or forgotten before its execution, or where other grounds of dispute may possibly arise.

The habit of making all agreements, orders and instructions in writing will avoid much confusion, many misunderstandings and possible litigation.

It is not always essential to prepare elaborate contracts. The degree of detail with which they should be prepared must depend largely upon the nature of the contract and the object for which they are written. Brief contracts with little or no detail, are warranted for circumstances under which competition is limited to contractors known to be responsible and experienced, and whose material, work or machinery can be taken on their merit with few questions as to the character of details.

§ 140. **A Contract Made by Letter.**—In simple transactions the contract may consist of an inquiry, an offer and an acceptance in the form of letters, which together will constitute a contract. A. B. C., a manufacturer of Rockford, Illinois, desires to arrange for a supply of coal for power purposes, and writes to various parties for prices. Among others, he writes X. Y. Z. of La Salle, Illinois, as follows:
Messrs. X. Y. Z., *Rockford, Illinois, Nov. 1, 1915.*

La Salle, Illinois.

Gentlemen:

We shall need during the year 1916, about twelve hundred tons of soft coal, mine run, for power and heating purposes. We desire the coal delivered on the side track at our factory in this city, as needed.

Will you kindly advise us at your early convenience if you will furnish this coal, and at what price?

Very truly yours,

A. B. C.

To this X. Y. Z. replies:

Messrs. A. B. C.,

La Salle, Ill., Nov. 10, 1915.

Rockford, Illinois.

Gentlemen:

In reply to your favor of the first instant: we will furnish you mine run coal from our Chapin mine near this city, twelve hundred tons of coal, more or less, as needed by you, delivered f. o. b. cars at our mine, for the sum of one dollar and fifty cents (\$1.50) per ton, freight allowed to Rockford.

It is understood that you are to advise us on or before the 15th of each month the amount of coal needed for the following month, and are to pay for the amount of coal delivered each month on or before the 15th of the following month.

Hoping to receive your order for the same we are

Very respectfully yours,

X. Y. Z.

A. B. C. having used mine run coal from Chapin mine is satisfied with the quality and price and writes:

Messrs. X. Y. Z.,

Rockford, Ill., Nov. 11, 1915.

La Salle, Illinois.

Gentlemen:

Your proposition of the 10th instant to furnish the coal for our factory for the year 1916, together with the terms of payment submitted, is satisfactory and is accepted.

Very truly yours,

A. B. C.

These letters constitute a contract, which is enforceable at law. A. B. C. must accept the "mine run coal" from the Chapin mine, and would probably have no recourse if the quality had deteriorated, as he has made no specification concerning quality, except that the coal be "mine run" and from the Chapin mine.

§ 141. **Contract by Acceptance of Letter.**—In general, the negotiations may not be as brief and to the point as in the above letters. The correspondence may be more voluminous, and it may be desirable to include all negotiations in a single instrument, in which case the desired end may be accomplished by a direct written offer and acceptance or by a more formal agreement, either of which should be signed in duplicate.

Contract consummated by acceptance of written offer.

Messrs. A. B. C.,
Rockford, Illinois.

La Salle, Illinois, Nov. 20, 1915.

Gentlemen:

In accordance with our previous correspondence, we agree to furnish you the amount of coal needed by your factory during the year 1916, about twelve hundred (1,200) tons more or less of two thousand (2,000) pounds each at the price of one dollar and fifty cents (\$1.50) per ton.

This coal shall be mine run and from our Chapin mine, and shall be delivered during the year 1916 as needed by you, f. o. b. cars on the side track at said mine, with freight allowed to Rockford.

Your order for each month's delivery must be sent on or before the 15th of the preceding month. Payments for all coal delivered during any month shall be made on or before the 15th of the month following. Letter in duplicate; please return one copy.

Very truly yours,

ACCEPTED:

X. Y. Z.

A. B. C.

§ 142. **A Formal Contract.**—

MEMORANDA OF AGREEMENT

It is mutually agreed between A. B. C. and X. Y. Z., this twentieth day of November, A. D., 1915, that the said X. Y. Z. shall furnish the said A. B. C., f. o. b. cars on the sidetrack of the Chapin mine, located near La Salle, Illinois, all coal that will be needed by him for

the use of his factory at Rockford, Illinois, during the year 1916, about twelve hundred tons (of 2,000 lbs.) more or less and the coal furnished shall be Mine Run Coal from said Chapin mine.

This coal shall be delivered during the year 1916, and as needed. The order for each month's delivery shall be sent on or before the 15th of the preceding month. The said A. B. C. agrees to pay the said X. Y. Z the sum of one dollar and fifty cents (\$1.50) per ton for said coal, with freight allowed from the Chapin mine to Rockford, Illinois, and all payments shall be made on or before the fifteenth of the month for all coal delivered during the preceding month.

	Signed	A. B. C.
Witness:	Signed	X. Y. Z.
D. C. W.		

§ 143. **Written Executory Contracts.**—The written executive contract may include all forms from the simple contracts, such as shown above, in which no technical specifications are included and the general conditions are few, to the elaborate contract necessary for the more complicated technical work that requires the preparation of numerous general conditions and many general and detailed specifications. In every case the contract or article of agreement should include, besides all requirements for a valid contract (see Sec. 101).

1. Parties to the contract (names, description, residence, etc.).

2. Subject matter:

Promises to be performed (work, materials, etc., to be furnished or done).

Counter-promises (payments to be made).

3. Time of performance.

4. Date of contract.

5. Signatures.

These matters are usually written in a more or less formal manner with certain set forms of introduction, declaration and closure, which are, however, legally unessential. The essential features of an agreement are simply those features necessary to indicate clearly the nature and extent of the obligations assumed by all parties concerned.

In many cases the purchaser may not be acquainted with the exact nature of the material or supplies which can be purchased from a certain miner, manufacturer or dealer, and may desire to secure material or supplies of a certain and definite kind, or he may desire certain work done, machinery furnished or structures built in a certain

way, for a certain purpose, or to accomplish certain results. There may also be certain responsibilities which the owner desires the contractor to assume, and the contractor may be asked to agree to certain conditions in regard to supervision, inspection, etc., and may also include certain further conditions in regard to the manner and methods of conduct of the work, and certain conditions in regard to the financial arrangements, payments, etc., may be desired.

In order that the owner may secure a definite offer for the undertaking, he should prepare a form of agreement which should contain all the conditions and specifications which may be necessary to describe clearly the undertaking and make his wishes in the premises definitely and distinctly manifest.

In case these conditions and specifications are brief, they may be written into the form of agreement but where they are elaborate and involved they may better be included by reference in the agreement and be prepared as one or more separate and distinct paper which may be included under several heads such as: *General conditions*, *General specifications*, and *Specifications for*

In any event the agreement either within itself or together with the attached papers should explain exhaustively all matters concerning the work and material, and should contain all covenants regarding supervision, conduct of the work, responsibility of either party, payments, guarantees and all specifications relative to the methods to be employed in its performance, and the materials, supplies and appliances to be furnished or used in the construction. Clearness, explicitness, inclusiveness, brevity, and proper arrangement are ends to be attained in their preparation. That and only that which it is desirable to covenant or to specify, should be included, and all covenants and specifications should be stated in the shortest and clearest terms compatible with a proper and clear understanding of the matter intended to be set forth.

The complete form of agreement, including all covenants and specifications, forms the basis for the negotiations for a contract. While in important work the form of agreement is usually prepared by one party to the contract without consultation with the other party, who in general is unknown, it must be so prepared that all its clauses will be acceptable or accepted by the contractor or no contract can be made without its modification.

Frequently the negotiations are preceded by an advertisement, the purpose of which is to call the attention to the undertaking, and often further information is given to those who desire to become contractors

through information included in a paper entitled "*Instructions to Bidders*," or "*Information to Bidders*," and, lastly, an offer to perform the undertaking may be made on a prepared form by which the various bidders offer to perform the undertaking under the proposed agreement, at a certain price or at certain prices which, being submitted in the same way, become comparative, unless other factors beside price, such as difference in quality of material, in workmanship, or in experience and reliability, become of importance. When a satisfactory proposal is received, it is accepted subject to the making of a written contract, in which event the "*Advertisement*," "*Instructions*," "*Proposal*," and "*Form of Agreement*," "*General Conditions*," "*General Specifications*," and "*Detailed Specifications*" are united, and when signed, constitute the contract. In some cases the drawings are also attached to the contract, but in most cases they are included by reference only.

§ 144. **Form.**—All agreements upon which bids are to be requested and contracts are to be based should be complete and should be so arranged as to lead to the utmost clearness in the understanding of what is necessary in making out proposals, submitting bids, entering into the contract, and executing the obligation. The arrangement should also be such as will facilitate ready reference to each and every point which is therein mentioned. Completeness is necessary on account of the fact that an acceptance of an offer, to legally consummate a contract, must be identical with the offer, and the fulfillment of an offer cannot be enforced if it involves the signing of a contract containing other and more onerous conditions than those on which the offer is based. Hence, if the papers are entirely complete and available at the time the proposal is made, the acceptance will usually consummate the contract. It is therefore also desirable that an acceptance be made provisional on the final consummation of the written contract.

A systematic and orderly method in the preparation of all the papers in connection with any contract is advisable, for by adopting such methods the ground can be completely and systematically covered and no details omitted. To facilitate uniformity and to prevent omission and misunderstanding, the arrangement of papers should usually be such that by the filing of blanks, the attachment of such supplementary specifications as the contractor may be required to furnish, the signing of the agreement, and execution of the bond, the contract can be consummated.

The agreement often includes the "*General Conditions*," and even the "*Specifications*." The general conditions are sometimes, and the

specifications often, written separately and confined to their own particular subject. The incorporation of either the general conditions or the specifications into the agreement is not essential, as a reference in the agreement to any papers, and their attachment thereto, make them equally a part of the contract. This is also true of the "*Advertisement*," "*Instructions*," "*Proposal*," etc. Even a proper reference to these papers, sufficient for their identification, is sufficient to make them a part of the contract, though unattached, but identification is complete if they are attached. A reference to the drawings, sufficient for identification, is all that is necessary, and the attachment of such drawings to the contract is unusual except in the case of standard machinery where photographs and illustrations may either be attached to or accompany the contract. These papers when printed are often printed and bound in the ordinary legal document form, that is, bound at the top and opening from the bottom. The pamphlet form, however, is largely used and is much handier for reference and much to be preferred to the legal form. When the papers are printed, and the legal form is used, the matter should usually be printed on only one side of the paper, as this arrangement offers greater facilities for examination and use. In the pamphlet form, both sides of each sheet may be utilized, the papers being therefore less bulky. In the arrangement of the matter in either case, the following order may be used:

Title: Front page of cover. (Description only.)

Advertisement: Second page of cover. (Sometimes printed on the back of the cover, and generally omitted in private contracts.)

Table of Contents (or Index).

Estimate of Amounts of Work to be Done. (Not essential, but often desirable.)

Instructions to Bidders. } Often included under either heading;
Information for Bidders } not used in simple contracts.

Form of Proposal.

Form of Bond with Proposal. (If one is used.)

Index (or Table of Contents).

Agreement.

General Conditions. }
General Specifications. } Either as a part of or separate from the
Detailed Specifications. } form of agreement.

Form of Bond with Agreement. (This may be, and usually is, a separate instrument.)

Form for Filing. (Back page of cover.)

When the advertisement is printed on the back of the cover, it should be so arranged that when the document is folded, the form of filing will be on one side and the advertisement on the other side. Sometimes the printed advertisement is cut from the paper in which it appears, and is fastened to the Form of Contract, which answers every purpose.

The bond to accompany the contract may be made a separate instrument and not included under the same cover as the other papers. This is certainly as well, as reference to the bond is seldom necessary, while the agreement and specifications are generally required for frequent reference.

§ 145. **General Clauses for Agreement.**—When the *general conditions* are not included in the *form of agreement* it should usually include only those important covenants that define, and fix the direct relation of the parties to each other in the most important matters. The following are suggested as the headings under which the data for an agreement may be prepared, subject to such modification as may be found desirable on different classes of work:

Outline for Agreements

1. Introduction of agreement and date of same.
2. Designation of parties, name, description and residence.
3. Declaration of agreement, parties and legal representation.
4. Exhibits as attached conditions, specification, drawings, etc.
5. Time of beginning and completion.
6. Liquidated damages.
7. Payment.
8. General provisions, bond, etc.
9. Final clauses, date or reference to date, signatures, seal, witnesses and acknowledgment.

Discussion of Articles of Agreement

I. *Introduction to Agreement and Date of Same.*—No specific form of introduction is required by law. A great variety of forms are in use among which may be noted the following:

- a. "This agreement made and concluded this — day of —, A. D. — by and between —."
- b. "This agreement made and concluded this — day of — — by and between —."
- c. "This contract made and concluded by and between — —."

The date on which a contract was made often becomes of much importance and should, therefore, be duly recorded.¹ In form "c" the date is usually written at the end of the contract.

2. *Designation of Parties, Names, Residences and Description of Same.*—No specific form is required for this particular clause of the agreement, but the parties to the contract should be so clearly designated that their residence and their relations to the contract will be fully understood. The following form is commonly used:

"By and between ——— (owner, corporation or agent) of the City of ———, County of ———, State of ———, party of the first part, and ——— (contractor, company or agent) of the City of ———, County of ———, State of ———, party of the second part."

When a contract is made by a corporation through its authorized representatives or agents, the relation and authority of the representatives or agents should be clearly stated in order that the authority may be properly investigated and clearly understood, and in order that the personal liability of the representatives or agents may be avoided.²

"By and between the Mayor, Aldermen, and Commonalty of the City of New York, acting by and through the Aqueduct Commissioners, by virtue of the power vested in them by Chapter 490 of the Laws of 1883, of the State of New York, parties of the first part, and ———."

The following example used by the Metropolitan Water and Sewerage Board differs somewhat in form from the preceding:

"———, ——— and ——— the Metropolitan Water and Sewerage Board duly constituted, and appointed under and according to the provisions of Chapter 168 of the Act of the Legislature of the Commonwealth of Massachusetts of the year 1901, herein acting for the Commonwealth, and without personal liability to themselves, and ——— hereinafter designated as contractor agree as follows:"

As different states have different statutory modifications of the common laws, it is important that the residence of both parties to a contract be stated. If the parties to a contract reside in different states, the place at which the contract is made will ordinarily fix the laws under which the contract is to be interpreted. This matter may be definitely fixed, however, by including in the agreement a statement that:

"This contract is to be regarded as a Wisconsin (or such other state as may be desired) contract."

¹ See Wait, *Engineering and Architectural Jurisprudence*, sec. 59.

² Wait, *Engineering and Architectural Jurisprudence*, secs. 29-39.

The term "party of the first part" conventionally applies to the person who contracts to sell, lease, or have performed the subject matter of the contract. The term "party of the second part" conventionally applies to the person who agrees to take or to purchase the article or to perform the contract. The use of these terms is frequently avoided by using instead some designation for the parties, such as "the company," "said contractor," "said owner," "said board," "said manufacturer," etc., etc.

3. *Declaration of Agreement—Parties and Legal Representatives.* This clause may also differ greatly in form. The following is a common form:

"Witnesseth that for and in consideration of the payments and agreements hereinafter mentioned to be made and performed by said Party of the First Part and under the penalty expressed in a bond, bearing even date herewith, the said party (or parties) of the Second Part agree with the said Party of the First Part at his (or their) own proper cost and expense to do all work and furnish all material called for by this agreement in the manner and under the conditions hereinafter specified."

Provisions for the death or incompetency of either party to a construction contract are usually provided for by definitely including "the heirs, executors, administrators, or assigns" of a person, or the "successors or assigns" of a corporation.³

Example—

"The said Party of the Second Part does hereby, for himself, his heirs, executors, administrators or assignees, promise and agree with the said Party of the First Part, its successors or assigns, at his own proper cost and expense, etc."

When a contract is made for the personal skill or professional knowledge of the contractor, it will be discharged by his death, otherwise the legal representative of the contractor is liable under it and reference to "heirs, administrator or executor" is unnecessary. Their mention in the contract is, however, evidence that the contract is not of such a personal character. In the same way the term "assignee" should be omitted either when "personal skill" is contracted for or when the agreement includes clauses prohibiting an assignment of the contract.⁴

4. *Exhibits.*—When the *general conditions* and *specifications* are not included in the *form of agreement*, a paragraph must be introduced

³ Ibid, secs. 7-12.

⁴ Ibid, secs. 13-16.

in the agreement by which it is stipulated that such conditions, specifications, etc., as may be essential are to be attached thereto and made a part thereof. For example:

"The parties to this agreement hereby stipulate that the following exhibits, which are attached hereto, are made a part hereof as though written herein:

The advertisement marked "Exhibit A."

The instruction to bidder marked "Exhibit B."

The form of proposal marked "Exhibit C."

The general condition marked "Exhibit D."

The general specification marked "Exhibit E."

The detailed specification marked "Exhibit F,"

The contract drawings marked "Exhibit G."

Exhibit G shall consist of drawings described and numbered as follows:
_____"

Here should follow the title and number or other distinctive mark of the various drawings.

When the general conditions are included in the form of agreement and the specifications are not, the clause concerning the exhibits make them a part of said agreement, such as the following:

a. "All work shall be done and all material furnished in strict conformity with appended advertisement marked 'Exhibit A,' instructions to bidders marked 'Exhibit B,' and specifications marked 'Exhibit C,' which are appended hereto and are hereby made a part of this agreement," or

b. "And it is further expressly agreed that the said excavation shall be made and said masonry shall be built, and all grading and filling shall be done, and all work, labor and material to be done and furnished under this contract shall be done and furnished strictly pursuant with and in conformity to the specifications hereto annexed which are made a part of this agreement."

5. *Time*.—When the general conditions are not included in the agreement and the time of completion is a matter of considerable importance, one of the articles in the general form of agreement is commonly devoted to this subject, although the further general conditions and stipulations in regard to delays, extension of time, and forfeitures are placed in the general conditions.

The article in the form of agreement may be essentially as follows:

The contractor further agrees to begin work within _____ days from the date of this agreement and to so prosecute the work that it will be entirely completed on or before _____. The maintenance of a greater progress in this work which will result in its completion within a specified time, is an essential feature of this contract, and the contractor agrees to do all

things and to take all necessary precautions to insure the rate of progress and the time of completion as stated and defined in this agreement and in the attached specification.

6. *Liquidated Damages.*⁵—The liquidated damages to be paid by a contractor for delays in the completion of the work undertaken by him to be completed in a given time under the stipulations outlined in paragraph 5 are usually of sufficient importance to be included as one of the articles in the form of agreement, even in cases where the general conditions are made a separate exhibit of the contract. This may be done by stipulations essentially as follows:

The party of the second part agrees to pay the party of the first part as liquidated damages the sum of —— dollars per day for each and every day that he delays the completion of the entire work to be done under this contract; and the party of the first part shall have the right to deduct the amount of any such liquidated damages from any moneys due or which may become due to the party of the second part under this contract, and to collect from the party of the second part and his sureties any excess of such liquidated damages over and above the amount that would be otherwise due the contractor.

7. *Payments.*—The payments to be made under an agreement are provided for in various ways. In some cases the form of proposal, after being accepted, is attached as an exhibit to the agreement, in which case it is stipulated in the agreement that payments shall be made in accordance with the prices set forth in the exhibit and in conformity to the general conditions and specifications attached to the agreement. In other cases, a schedule of unit prices and estimated quantities is included as one of the articles in the general form of agreement. This is apparently done for the reason that the payments are a most important factor and that such importance warrants their insertion into the agreement itself. These two forms are shown in the following examples:

(a) For and in consideration of the faithful performance of the contract by the party of the second part in full accordance with the plans and specifications, and with the stipulations herein contained or attached hereto, the party of the first part agrees to pay to the party of the second part the prices set forth in the form of proposal, which is marked "Exhibit C" and attached hereto and made a part hereof. Said payments shall be made in accordance with the general conditions and specifications attached hereto.

(b) For and in consideration of the faithful performance of this contract by the party of the second part in full accordance with all of the provisions of the same as set forth in this agreement and in the various ex-

⁵ See also Paragraph M, Sec. 153.

hibits attached hereto, the party of the first part agrees to pay to the party of the second part, in the manner and at the times hereafter set forth, and at the rates mentioned and described in the following schedule of unit prices, to wit:

SCHEDULE OF UNIT PRICES

Item	Class	Unit of Quantity	Unit Price
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8. *Provisions for Bond, etc.*—The provisions for bond are sometimes included under paragraph 3, as shown in the examples given therein. In other cases they are stipulated in an article at the end of the form of agreement, essentially as follows:

“Contract and Bond.—It is further agreed by the parties to this contract that this contract shall be executed in triplicate, one copy being retained by the party of the first part, one to be delivered to the party of the second part, and one to be delivered to the chief engineer.

“The party of the second part further agrees to execute a bond in the sum of ——— dollars for the faithful performance of the work and in the form provided for that purpose, and it is agreed that this contract shall be void until such bond is signed, delivered, and approved by ———.”

9. *Final Clause and Signatures.*—In the final clauses and signatures it is important to see that all legal requirements are duly complied with. In the case of corporations, either public or private, the rights of the parties signing the agreement for such corporations should be carefully determined in order that the agreement may be a legal and binding obligation on such corporation. In some cases a seal is desirable or essential; in other cases witnesses to the signature are necessary; and in still other cases, acknowledgment before a notary public is required.

“In witness whereof the parties to these presents have hereunto set their hands and seals the day and date first above written.”

Where the date is not inserted in the first part of the contract, the final clause should be as follows:

“In witness whereof the parties to these presents have hereunto set their hands and seals this ——— day of ———, A. D. 19—.”

CHAPTER XIV

GENERAL CONDITIONS OF THE CONTRACT

§ 146. **Outline.**—The general conditions to be included in any contract will depend on the character and extent of the work and will usually vary with each special case. These conditions may be embraced under seven subdivisions as follows:

- I. Definitions.
- II. Rights and Responsibilities of Owner.
- III. Engineer's Authority.
- IV. Prices and Payments.
- V. Contractor's Responsibilities.
- VI. Conduct of Work.
- VII. Police and Sanitary Regulations.

These divisions, the titles of which, in general, indicate the nature of the conditions which should be included thereunder, may be subdivided as the conditions in each particular case require. In section 147 these main divisions are further subdivided and as given and discussed in the following sections include all of the general conditions usually necessary for extended contracts. In most contracts many of the conditions herein discussed will not apply and only such should be included as are pertinent to the particular conditions for which the contract is purposed.

§ 147. **Outline of General Conditions.**

- I. Definitions.
- II. Rights and Responsibility of Owner.
 - A. Inspection and supervision.
 - B. Right of access and collateral works.
 - C. Changes, alterations and extra work.
 - D. Discrepancies and omissions.
 - E. Property, material, etc., furnished by first party.
- III. Engineer's Authority.
 - A. To supervise and direct work.
 - B. Assistant engineer and inspector.
 - C. To furnish lines and grades.
 - D. To determine quantities and measurements.
 - E. To define terms and explain plans.

- F.* To provide for emergencies.
- G.* Engineer cannot waive obligations.
- H.* To modify methods and equipment.
- I.* To retain imperfect work.
- J.* Arbitration.

IV. Prices and Payments.

- A.* Estimates and payments.
- B.* Delayed payments.
- C.* Extra work.
- D.* Contract prices.
- E.* Bond and sureties.
- F.* Guarantees.

V. Contractor's Responsibilities.

- A.* Persons interested in contract.
- B.* Personal attention of contractor.
- C.* Contractor's address.
- D.* Agents, superintendents and foremen.
- E.* Compliance with laws.
- F.* Protection against negligence and damage.
- G.* Protection against claims for labor and material.
- H.* Infringements of patents.
- I.* Assignment.
- J.* Termination of contract if abandoned, assigned, delayed or violated.
- K.* Time and order of completion.
- L.* Rate of progress.
- M.* Liquidated damages.

VI. Conduct of Work.

- A.* To keep plans and specifications on the work.
- B.* Character of employees.
- C.* Sustain all losses and damages.
- D.* To protect work.
- E.* Hindrances and delays.
- F.* To remedy defective work.
- G.* Construction plant.

VII. Police and Sanitary Regulations.

- A.* Sanitation.
- B.* Intoxicants.
- C.* Camps.

§ 148. Definitions.

Interpretation of Phrases and Definitions or Other Similar Title.—

It is desirable to include in the general conditions definitions of the various phrases or terms used throughout the contract, such as "Party of the First Part," "Party of the Second Part," "Contractor," "Engineer," "Chief Engineer," "Inspector," "Owner," "Company," "City," and any other words, terms or abbreviations which are not otherwise fully defined. This may be done by inserting paragraphs descriptive of each title or terms as follows:

"Whenever the word(s) or the expression 'Party of the First Part' or 'First Party' are used in this contract, it shall be understood as referring to (here describe the person, company or corporation entering into the contract to have the same performed)"

"Whenever the word 'contractor' or the expressions 'Party of the Second Part,' or 'Second Party,' are used it shall be understood to mean the person, persons, co-partnership or corporation who has agreed to perform this contract or to his or their legal representatives."

"Whenever the word 'Engineer' is used in this contract it shall be understood as referring to the Chief Engineer of the party of the first part, or such other engineer, superintendent or inspector as may be authorized by said first party to act in any particular."

"Whenever the words 'Directed,' 'Required,' 'Permitted,' 'Ordered,' 'Designated,' 'Considered Necessary,' 'Prescribed,' or words of like import are used, it shall be understood that the direction, requirement, permission, order, designation, or prescription, etc., of the Engineer is intended; and similarly, the words 'Approved,' 'Acceptable,' 'Satisfactory,' or words of like import, shall mean approved by, or acceptable or satisfactory to, the Engineer."

§ 149. Rights and Responsibilities of Owner.

A. Inspection and Supervision.—Unless the owner is willing to assume responsibility for the negligence of the contractor and the result ultimately to be accomplished under the contract, he must not impose his control of the manner and method by which the results are to be accomplished.¹

The retention of the control of men and method by the owner destroys the relations of "Owner and Independent Contractor" and establishes the relation of "Master and Servant" or of "Principal and Agent."²

The owner may direct as to the result of the undertaking, and may prescribe in the specifications and plans the method and manner of do-

¹ Wait, *Engineering and Architectural Jurisprudence*, Sec. 651.

² *Ibid*, Secs. 653 to 659 and Secs. 665 to 666.

ing the work. He may delegate the direction and supervision of the work to his authorized agent or agents, that is to his engineers, inspectors, etc. In this case the contractor by accepting the contract, accepts such methods and manner of doing the work as his own.³ Care should be exercised in including in the contract and specification, such requirements as are considered necessary as to the method of doing the work and as to the final result to be obtained, but any assumption of detailed control of manner or methods during the construction of the work should be studiously avoided, if, as is usually the case it is desired to fix the responsibility for the conduct of the work and for the results of the same, on the contractor.⁴

Such supervision and inspection as may be desired must be specified and described in the agreement. Any aid that the contractor is to furnish in connection with such inspection must also be clearly specified.

"It is agreed by the party of the second part that the party of the first part shall be, and is hereby authorized to appoint from time to time such engineer, superintendent or inspector as the said first party may deem proper, to inspect the material to be furnished and the work to be done under this agreement and in accordance with the specifications therefor. The contractor shall furnish all aid and assistance required by the engineer, superintendent or inspector for the proper inspection and examination of the work and all parts of the same. The contractor shall regard and obey the directions and instructions of any engineer, superintendent or inspector so appointed when the same are consistent with the obligations of this agreement, and of the specifications attached hereto, or said contractor shall immediately appeal to the Chief Engineer for his decision, and shall respect such decision when so rendered."

B. Right of Access and Collateral Work.—Unless otherwise provided, an agreement for construction will ordinarily give the contractor full possession of the building, plant or field of operation, and if other contractors are to furnish material or to do work which may result in more or less interference, proper provision should be made in the agreement to retain this right.

This stipulation should reserve the right of access to the work when such reservation is necessary or desirable. The reservations made, however, should not be such as may needlessly cause possible trouble or extra expense to the contractor.

"The party of the first part reserves the right to enter the property or location on which the works herein contracted for are to be constructed or

³ Ibid, Secs. 660 to 664.

⁴ Ibid, Sec. 667.

installed by such agent or agents as it may elect for the purpose of constructing or installing such collateral works as said first party may desire. Such collateral works will be constructed or installed with as little hindrance or interference as possible with the party of the second part. The party of the second part hereby agrees not to interfere with or prevent the performance of such collateral work by the agent or agents of the party of the first part, or to claim any extra compensation or damages by delays or hindrances which be caused by the construction or installation of such collateral work."

"..... and his engineers, agents or employees may, for any purpose, and other contractors may, for all the purposes which may be required by their contracts, enter upon the work and the premises used by the contractor, and the contractor shall provide safe and proper facilities therefor. Any differences or conflicts which may arise between the contractor and other contractors of in regard to their work shall be adjusted and determined by the engineer."

C. Changes, Alterations and Extra Work.—Provisions may be made for changes, alterations or extra work, but when so made, they may be exercised only in the manner and to the extent provided in the agreement.⁵

It should be noted, however, that any unauthorized changes in the contract will release the sureties on the contractor's bond, but that said sureties will not be released from the contract by changes which are duly authorized therein.⁶

"The said party of the second part further agrees that the said first party may make such alterations as said party may see fit in the line, grade, form, dimensions, plan or material of the work herein contemplated, or any part thereof, either before or after the commencement of the construction.

"If such alterations diminish the quantity of the work to be done, they shall not constitute a claim for damages or anticipated profits on the work that may be dispensed with. If they increase the amount of work, such increase shall be paid for according to the quantity actually done, and at the prices established for such work under this contract; provided, however, that if said first party shall make such changes or alterations as shall make useless any work already done or material already furnished or used in said work, that said first party shall recompense said party of the second part for any material or labor so used. No work shall be regarded as extra work unless it is ordered in writing by the Chief Engineer and endorsed by , and with the agreed price for the same specified in said order, provided said price is not otherwise determined by this contract. All claims for extra work shall be made to said first party within sixty days after its completion, and, failing to make such claims within this time, all rights of the contractor for extra pay for such work shall be forfeited."

⁵ Wait, *Engineering and Architectural Jurisprudence*, secs. 551 to 571.

⁶ *Ibid*, Secs. 20, 21 and 576.

It is exceedingly undesirable to make changes in work which has been let under a contract, but in many cases such changes become necessary on account of the development of conditions which have not, and, in many cases could not, be readily determined in advance of the beginning of the work. Radical changes, which materially affect the nature of the contract, either by a large increase or a considerable decrease in the quantity of the work or by a change in its character are unfair and may result in serious injustice to the contractor. Such changes should, therefore, be limited in amount and such limits should be as small as safety will permit and should seldom exceed 25 per cent. If larger changes become necessary, they should be accomplished by the negotiations of a supplementary contract.

"The said party of the second part further agrees that the said first party may make such alterations as said party may see fit in the line, grade, form, dimensions, plan or material of the work herein contemplated, or any part thereof, either before or after the commencement of the construction. It is agreed, however, that the change in the amount or quantity of any item shall not exceed twenty-five per cent. (25%) of the estimated amounts on which the bids were compared, and that if any changes are made to exceed this amount such changes shall be based on a supplement agreement to be made therefore.

"If such alterations diminish the quantity of the work to be done, they shall not constitute a claim for damages or anticipated profits on the work that may be dispensed with. If they increase the amount of work, such increase shall be paid for according to the quantity actually done, and at the prices established for such work under this contract; provided, however, that if said first party shall make such changes or alterations as shall make useless any work already done or material already furnished or used in said work, that said first party shall recompense said party of the second part for any material or labor so used. No work shall be regarded as extra work unless it is ordered in writing by the Chief Engineer and endorsed by , and with the agreed price for the same specified in said order, provided said price is not otherwise determined by this contract. All claims for extra work shall be made to said first party within sixty days after its completion, and, failing to make such claims within this time, all rights of the contractor for extra pay for such work shall be forfeited."

D. Discrepancies and Omissions.—Where discrepancies are found between plans and specifications, which is frequently the case, in minor matters, at least, the court will determine, if possible, the actual intention of the parties at the time of signing the agreement. Provisions may be and usually are made that the engineer may explain such discrepancies and may decide which shall prevail.⁷

⁷ Wait, Engineering and Architectural Jurisprudence, secs. 225 to 235.

on the drawings or described in the specifications but which may be fairly implied as included in any item of the contract, shall be done and furnished by the contractor without additional charge therefor."

Provisions may also be included in the agreement for the correction of errors or omissions in matters or things which are fairly implied by the agreement, and the same rules hold as in the case of discrepancies.

It is evident that the greatest care should be exercised to see that the plans and specifications fully agree and that discrepancies are practically eliminated, also that the plans and specifications are complete. If care is exercised in these regards, the chance of serious discrepancies or omissions is remote. When plans and specifications are only general in character and show evidence of hasty or careless preparation contractors should refuse to bid upon the same if the engineer is empowered by the contract to determine discrepancies and require omissions to be furnished at his discretion and without arbitration.

These clauses should be so written as to prevent the possibilities of unjust claims for minor discrepancies or immaterial omissions but should not impose upon the contractor the expense of rectifying the mistakes of the engineer.

"Discrepancies: Should there be any discrepancy between plans and specifications for the work herein specified, the engineer shall define which is intended to apply to the work in hand, and the contractor shall be bound by such decision."

"Omissions: Any work or material not herein specified but which may be fairly implied as included in the contract, of which the Chief Engineer shall be the judge, shall be done by the contractor without extra charge."

"This agreement including the specifications, plans and estimates is intended to be sufficient to show all work to be done and material to be furnished hereunder. The quantities of the various classes of work and material to be done and furnished under this contract are approximate and are to be used only as a basis for estimating the probable cost of the work and for comparing the proposals offered for the work, on a uniform basis. It is understood and agreed that the actual amount of work to be done and material to be furnished, under this contract may differ somewhat from these estimates, and that the basis for payments under this contract shall be the actual amount of such work and material done and furnished.

"The contractor agrees that he will make no claim for damages, anticipated profits or otherwise on account of any differences which may be found between the quantities of the various kinds of work and material actually done or furnished under this contract and the estimated quantities contained in this agreement. It is further agreed that it is the intent of this contract that all work must be done and all material must be furnished in accordance with the best practice, and in the event of any discrepancies be-

tween the plans and specifications, or otherwise, or in the event of any doubt as to the meaning of any portion of the contract, specifications or plans, the engineer shall define which is intended to apply to the work, and the contractor shall be bound by such decision. Any work or material not shown on the drawings or described in the specifications but which may be fairly implied as included in any item of the contract, shall be done and furnished by the contractor without additional charge therefor."

E. Property, Material, etc., to be Furnished by First Party.—

The party of the first part should, in general, furnish the real estate and rights-of-way required for the purpose of the work. The first party may desire to furnish other material or supplies which may be on hand or which it may be desirable to furnish through manufacturers or other contractors. The latter furnishings are usually described in the specifications. The real estate or rights of way are usually described in the *general conditions*.

"The party of the first part will furnish all real estate and rights of way reasonably necessary for the work, including land needed for the construction, for borrow pits, for waste dumps, for camp sites and for access to the work.

"In case of serious delays in the acquisition of the necessary land for this purpose, an extension of time will be granted the contractor sufficient to compensate therefor. The contractor shall have no compensation for minor delays or interruption caused by the failure to secure such land but shall receive compensation for the actual losses occasioned by serious delays."

§ 150. Authority of the Engineer.

The engineer is commonly designated as the arbiter to decide questions of quantity, quality, workmanship, and any other questions which may arise between the parties to a contract. Commonly, the specifications attempt to make the decisions of the engineer "final and conclusive" on the contractor, and often on both parties.⁸ The decisions of assistants must always be subject to appeal to the Chief Engineer, and frequently the decisions of the Chief Engineer are made subject to adjustment by a board of arbitration. No agreement on the part of the contractor can make such decision "final and conclusive" if such decisions are unlawful, for a man cannot legally sign

⁸ Mutuality is the essence of a valid contract and this must exist not only in the contract as a whole but in regard to each obligation of the contract. That is, every obligation resting on one party must be in consideration of a promise or act of the other party. Neither party is bound unless both are bound.

If, therefore, the engineer is made the arbitrator of the contract on the part of the contractor his authority is at least doubtful unless the contract also provides that the first party is also bound by his decision.

away his own rights to his "day in court." In preparing such clauses or stipulations, the following conditions should be kept clearly in mind:

The authority that the engineer can exercise in regard to any contract is confined to those functions conferred upon him by the contract stipulations which must be strictly complied with.

Under the usual form of contract, the engineer is commonly endowed with two duties,—*first*, as an agent of the owner, and *second*, as an arbiter of the terms of the contract.⁹

The engineer's authority does not extend to anything not expressly provided for in the contract, and he cannot vary its terms in any way.¹⁰ If so stipulated, the engineer may determine quantities and classifications, but he cannot act arbitrarily in the premises and must use the methods and classifications prescribed in the contract.¹¹ If so stipulated, he may determine the quality and workmanship of the work done.¹² The right of the engineer or of a board of arbitration to determine any question in dispute, cannot be fixed to the exclusion of a review by courts of law or of equity, but such determination may be made a "condition precedent" to such review.¹³

In the supervision and direction of construction work the engineer must exercise certain judicial functions in interpreting the clauses of a contract, but all specifications should be so drawn as to limit this function to the greatest possible extent. When the engineer is made the arbiter of a contract, he should so far as possible, eliminate prejudice and bias and represent not only his client but the contractor as well, in order to see that the contract is carried out with justice to all concerned. It must, however, be practically recognized that the engineer is not an unbiased party. Employed by his client to secure satisfactory work which, as a rule, he has designed, and for which he has prepared the specifications, his tendencies are to so interpret the specifications as to bring about the results he desires, and any clauses which he has therefore rendered obscure are liable to be interpreted in the favor of his client rather than of the contractor.

When a specification is definite, the honest engineer can give but one opinion. The function of the engineer therefore is not that of the legal judge but of the expert judge. (See Sec. 125.)

⁹ Wait, Engineering and Architectural Jurisprudence, secs. 370 and 371.

¹⁰ Ibid, secs. 372 to 380.

¹¹ Ibid, secs. 381 to 387.

¹² Ibid, secs. 388 to 390.

¹³ Ibid, secs. 400 to 417.

A. Supervision and Direction of Work.—The function of the engineer is to supervise and direct the work of construction and to see that the same corresponds with the requirements of plans, specifications and contract. The right of direction reserved to the engineer in the contract should not be so extended as to relieve the contractor of the responsibility imposed thereunder, nor should it be such as to permit the engineer to unnecessarily hamper or delay the execution of the work. The common specification that, "The work must be commenced and carried on at such points and in such order or precedence as may be directed by the engineer," is usually unnecessary and unjust. In most cases if desirable, it is quite possible to prescribe the point or points at which the work shall be begun and the order or precedence in which it is necessary that it shall be constructed. The right of the engineer to change this order should be limited to conditions where contingencies may arise that clearly make such a change necessary.

"Supervision: It is mutually agreed between the parties to this contract that the engineer shall supervise and direct all work included herein. To prevent all disputes and to discourage litigation, it is further agreed by and between the parties to this contract that if it cannot be otherwise agreed, the chief engineer shall in all cases determine the amount of the quantities of the several kinds of work which are to be paid for under this contract, and he shall determine all questions in relation to said work and the construction thereof, and he shall in all cases arbitrate every question which may arise relative to the execution of this contract on the part of said contractor, and his estimate and findings shall be the condition precedent to the right of the party of the second part to any action on the contract and to any rights to receive any money under this contract."

"Duration of work: Whenever it is necessary, in order to assure the safe and proper construction of the work, the engineer shall determine the times and seasons and the order of precedence under which the work shall be done. Where the first party is having other work done, either by contract or by its own force, the engineer may direct the manner of constructing the work done under this contract, in order that conflicts may be avoided and the various works being done for the party of the first part may be harmonized."

B. Assistants and Inspectors.—In large work a considerable number of assistant engineers, superintendents and inspectors may be required to see that the work is properly performed. In general, their activities should be limited to the special work to which they are assigned.

"The word 'engineer' shall mean the chief engineer of the party of the first part, or his duly authorized agent, assistant engineer, superintendents,

and inspectors acting severally within the scope of the particular duties assigned to them."

C. Inspection.—Care should be exercised by engineers in charge of large works requiring a number of superintendents and inspectors to fully advise their subordinates as to the extent and limitation of the authority they are to exercise and to furnish instructions as a basis for their work. Instructions should be in writing in order to provide a permanent record and for frequent reference. The inspector when unfamiliar with his work should request full instructions and should refer all doubtful points to his superior. He should avoid making hasty decisions and should not be too ready to accept suggestions of the contractor or of others not in authority. Care in ascertaining his duties and in determining the methods and manner in which the work should be done at the inception of the work, will avoid errors, and embarrassment, increase his knowledge and efficiency and result in his more rapid advancement. The assumption of a knowledge or experience he does not possess and a consequent failure to make necessary inquiries will result in unsatisfactory service and frequently in the loss of position.

Inspectors.—In most large public works where numerous inspectors are necessary or desirable, men have often to be employed for such positions, who have little or no professional knowledge or practical experience on the work in question. This is apt to be true especially in public work where appointees to such positions are frequently placed by politicians without much regard for ability or sometimes for integrity. Such inspectors frequently are given or assume an authority which they should not possess and sometimes utilize their position to harrow and annoy the contractor, either through their ignorance or occasionally for purposes of petty graft. To cover such conditions, it has been suggested by Mr. Ernest McCullough¹⁴ that a clause be introduced in the general conditions somewhat as follows:

"It is mutually agreed that the inspectors on this work shall not be regarded as deputy engineers, but their duties shall be to report to the engineers in charge any deviation from the specifications, and when necessary to order the work stopped until the engineer in charge can give his opinion concerning any disputed question."

"All decisions regarding the character of work to be done or material to be furnished or the interpretation of the specifications, shall be referred to the engineer in charge, and the inspectors shall make no changes or deviations from the specifications or allowances of any kind, without written au-

¹⁴ See Eng. News Supplement, vol. 51, p. 233.

thority to that effect from the engineer in charge. It is furthermore agreed by the parties to this contract that in case the engineer in charge is obliged to be absent from the work for a considerable time and it becomes necessary to delegate his authority during his absence to any one of said inspectors, said inspector shall be appointed in writing and such authority shall cease without notice on the return of the engineer."

D. Lines and Grades.

"All lines and grades shall be furnished by the engineer but the contractor shall provide stakes and such ordinary labor as may reasonably be required by the engineer to assist him in such work. Whenever necessary, work shall be suspended to permit of this work, but such suspension will be as brief as practicable and the contractor shall be allowed no extra compensation therefor. The contractor shall give the engineer ample notice of the time and place where lines and grades will be needed. All stakes, marks, etc., shall be carefully preserved by the contractor and in case of their destruction or removal by him or his employees, such stakes, marks, etc., shall be replaced by the engineer at the contractor's expense."

E. Quantities and Measurements.—The subject of measurements is prolific of trouble in specifications unless the methods used are fully understood. It is always desirable to assure such understanding by a specification which shall expressly state the method to be used. This is commonly done by the general statement

"No extra or customary measurements of any kind will be allowed in measuring work under this contract, but the actual length, the solid contents, the number and weight only shall be considered, unless otherwise specifically provided."

Frequently in various artisans' work, various customary methods of measurements are applied by the trade or by general usage, which in general, are an attempt to equalize the difficult portions of the work and reduce them to the basis of plain work by making extra allowances where such work becomes unusually expensive. Such methods are justifiable in themselves, if fully understood by both parties to the contract and indeed simplify, to a considerable extent, the estimate of the parties who are used to making their figures on the basis of such measurement. As they are usually readily understood and can be easily applied by the engineer, and more easily applied by the contractor who has been accustomed to them, it would seem desirable that they should be used wherever such use seems feasible. In any event, the matter should be made plain and if such rules are to be used, it should be specifically so stated.

If on the other hand such rules are to be ignored, then a clause similar to that previously mentioned should be inserted, so that no

misunderstanding can possibly exist. Even where the method of measurement may seem almost beyond question, differences of understanding may arise. For example, the measurement of the surface area of a pavement would seem a very simple affair on which the engineer and contractor could hardly disagree. Where manholes, catch basins and street railway tracks are located on the street, the expense of fitting around these structures is usually greater than would be the extra cost of pavement which would be constructed were these structures removed; no allowance is therefore usually made in the amount of paving estimated for the surface occupied by these structures, but if the surface area of the same is deducted, a considerable extra expense should be added to the contract price named for the remainder of the pavement.

The same difficulty exists to a greater or less extent in the measurements of a great many other structures, such as stone masonry, brick walls, etc. The clauses modifying measurement should therefore be made explicit, so that they can be literally interpreted:

F. To Define Terms and Explain Plans.—Even when much care has been taken in the preparation of plans and in the writing of specifications it is commonly found that difference of opinion will arise in regard to their meaning and intent. It is essential, therefore, that the engineer shall be authorized to define the meaning of words and terms, and indicate the limits necessary for their fulfillment under the contract. He should also be authorized to explain the meaning and intent of the plans and harmonize any apparent discrepancies between the plans and specifications.

“Definition of Terms: Whenever, in the specifications or drawings accompanying this agreement, the terms or descriptions of various qualities relative to ‘finish,’ ‘workmanship,’ or other qualities of similar kind which cannot from their nature be specifically and clearly described and specified, but are necessarily described in general terms to be ‘satisfactory,’ ‘first class,’ ‘workmanlike,’ or described by other terms, the fulfillment of which must depend on individual judgment, then, in all such cases, any question of the fulfillment of said specification shall be decided by the chief engineer, and said work shall be done in accordance with his interpretation of the same and to his full satisfaction and approval, and he shall in all cases be the judge of the fulfillment thereof.”

“Explanation of Plans: Whenever any misunderstanding shall arise concerning the meaning and intent of any of the drawings furnished or to be furnished to the contractor under this agreement, or whenever any apparent discrepancies shall arise between said plans and the contract and specifications, the chief engineer shall explain the same, and said explanation shall be final and binding on both parties to this contract. Said engineer

may amend or correct any errors or omission in the drawings or specifications when such amendment or correction is necessary to bring out the meaning and intent which is clearly indicated by a reasonable interpretation of the same."

G. Emergencies.—On important work, where possible hazards to life and property may arise, or where the welfare of the work may depend upon the precautions taken by an individual contractor, such precautions may be neglected, and it is customary and desirable under such conditions to provide that the engineer may do whatever is necessary to prevent such possible contingencies. The necessity of exercising such a right seldom occurs, but the right to provide such precautions is very essential.

"*Emergencies:* Whenever, in the opinion of the engineer, the contractor has not taken sufficient precaution for the safety of the public or the protection of the works to be constructed under this contract, or of adjacent structures or property which may be injured by processes of construction on account of such neglect, and whenever, in the opinion of said engineer, an emergency shall arise and immediate action shall be considered necessary in order to protect public or private, personal or property interests, then, and in that event, the said engineer, with or without notice to said contractor, may provide suitable protection to said interests by causing such work to be done and material to be furnished and placed as shall furnish such protection as said engineer may consider necessary and adequate.

"The cost and expense of such work and material so furnished, shall be borne by said contractor, and if the same shall not be paid on presentation of the bills therefor, then said costs shall be deducted from any amounts due or which may become due said contractor.

"The performance of such emergency work under the direction of the engineer shall in no way relieve the contractor from any damages which may occur during or after said precaution has been duly taken by said engineer."

H. Preliminary Approval.—Where various assistants and inspectors are employed in connection with the execution of work, it is desirable to specifically limit their power of acceptance of work done to the stipulations of the contract.

"No engineer, superintendent or inspector shall have any power to waive the obligations of this contract for the furnishing by the contractor of good material and of his performing good work as herein described in full accordance with the plans and specifications. No failure or omission of any engineer, superintendent or inspector to condemn any defective work or material shall release the contractor from the obligation to at once tear out, remove, and properly replace the same at any time upon the discovery of said defective work or material."

I. Right of Engineer to Modify Methods and Equipment.—The right to modify the contractor's method of work and equipment is a

serious reservation which should be included only when the nature of the work makes it necessary for safety that the work shall be done within a given time or by such means that such safety shall be secured. Such arbitrary requirements can be advantageously made a part of the general conditions only when the standing and experience of the engineer are sufficient to make him a reasonable judge of the necessities of the case.

“Right to Modify Methods and Equipment: If at any time the methods or equipment used by the contractor are found to be unsafe or inadequate for securing the safety of the workmen or other persons who may be endangered thereby, or to secure the quality of work or the rate of progress required under this contract, the engineer may order the contractor to increase their safety or to improve their character and efficiency, and the contractor shall comply with such orders.

“If at any time the working force of the contract is inadequate for securing the progress herein specified, the contractor shall, if so ordered, increase his force or equipment, or both, to such an extent as to give reasonable assurance of compliance with the schedule of progress.

“The failure of the engineer to make such demands shall not relieve the contractor of his obligations to secure the safety of his men, the quality of the work, and the rate of progress required by this contract.”

J. Right to Retain Imperfect Work.—The contract usually provides that all work which is not in accordance with the plans and specifications shall be taken down and rebuilt in accordance therewith. Under some conditions the removal of work constructed may so greatly impede the progress of the entire work or involve such other losses and damages that it may be desirable or essential to retain the work, even with the imperfection rather than to suffer the consequent loss of its removal and replacement. Whenever such cases may arise it is desirable to include in the general conditions a stipulation, that if the imperfections are not of sufficient magnitude to warrant its removal and reconstruction or if such conditions arise as to make such removal and reconstruction impracticable or dangerous the engineer shall have the right to allow the same to remain, but shall be empowered to make such reasonable deduction from the contract price of the same as the defect of workmanship, material or construction may fairly warrant.

“If any part or portion of the work done or material furnished under this contract shall prove defective and not in accordance with the plans and specifications, and if the imperfection in the same shall not be of sufficient magnitude or importance as to make the work dangerous or undesirable, or if the removal of such work will create conditions which are dangerous or undesirable, the engineer shall have the right and authority to retain such work, but shall make such deductions in the final payment therefor as may be just and reasonable.”

K. Arbitration.—One of the serious uncertainties in estimating the cost of work by contractors arises when the decisions of the various questions which may arise under a contract are left to the decision of the engineer. Where the contractor has done previous work under a certain engineer, his character and the decisions which he will give under the various conditions of contract work may be known, but when a bid is made under an engineer who is unknown or under an engineer who is young and inexperienced, the uncertainties become quite serious and a considerable addition must be made to the prices bid to cover the possibilities of unjust requirements. (See Sec. 126.)

In most work it is essential that the work should proceed, and it is desirable as a general rule that the decision of the engineer shall be accepted and complied with so far as the immediate action of the contractor is concerned. It is desirable however, both on account of its effect upon the prices bid and on account of fairness that, in all matters of moment where serious differences may arise between the contractor and engineer, some provision be made by which an appeal can be taken to a board of arbitration. Where arbitration is provided, the clause in regard to the engineer's decision may be included essentially as follows:

"Engineer's Decisions: The engineer shall, within a reasonable time, decide all questions or claims of either party to this contract and all matters relating to the execution and progress of the work or the interpretation of the plans, specifications and contract.

"Unless otherwise provided, all the engineer's decisions shall be subject to arbitration."

The following specification on this subject is written in general accordance with the specification for arbitration recommended by the American Institute of Architects:

"Arbitration.—Unless otherwise specifically provided, all questions in dispute under this contract shall be submitted to arbitration at the choice of either party to this contract. The general procedure shall conform to the laws of the state in which the work lies; and wherever permitted by law, the decision of the arbiters may be filed in court to carry it into effect.

"If the engineer fails to make a decision within a reasonable time, an appeal to arbitration may be taken, as if his decision had been rendered against the party appealing. In such cases and in a case of an appeal from the engineer's decision, the demand for arbitration shall be filed with him in writing within ten days thereafter; and in no case later than the time of final payment.

"The parties may agree upon one arbiter, otherwise there shall be three: one named in writing by each party, and the third chosen by the two arbiters so selected; or if the arbiters fail to elect a third within ten

days, he shall be chosen by the presiding official of the nearest Bar Association. Should the party demanding arbitration fail to name an arbiter within ten days of the demand, his right to arbitrate shall lapse, and the decision of the engineer shall be final and binding on him. Should the other party fail to choose an arbiter within ten days, the engineer shall appoint such arbiter. Should either party refuse or neglect to supply the arbiters with any papers or information demanded in writing, the arbiters are empowered by both parties to take *ex parte* proceedings.

"The arbiters shall act with promptness. The decision of any two shall be binding on both parties to the contract. The decision of the arbiters upon any question subject to arbitration under this contract shall be a condition precedent to any right of legal action.

"The arbiters, if they deem the case demands it, are authorized to award the party whose contention is sustained, such sums as they deem proper for the time, expense and trouble incident to the appeal; and if the appeal was taken without reasonable cause, damages for any delay occasioned. The arbiters shall fix their own compensation, unless otherwise provided by agreement, and shall assess the cost and charges of the arbitration upon either or both parties. The award of the arbiters must be in writing, and if in writing shall not be open to objection on account of the form of the proceeding or the award."

§ 151. Prices and Payments.—The stipulation in regard to the financial conditions under which the work is to be done usually relates to the conditions under which estimates have to be given and payments made, together with such other special stipulations concerning guarantees, bonds and signing of contract as it may be desirable to include.

A. Estimates and Payments.

"In order to enable the contractor to prosecute the work to advantage, an estimate in writing will be made by the engineer once a month of the amount of work done and material furnished (and material delivered on the ground and to be used in the completed work), and of the value thereof according to the terms of the contract. The first estimate shall be of the amount or quantity in value of the work done since the party of the second part commenced the performance of this contract, and every subsequent estimate, except the final one, shall be of the amount or quantity and value of work done since the last preceding estimate was made. No such estimate of amount or quantity shall be required to be made by strict measurement or with exactness but may be approximate only.

"Upon the approval of said estimate by the chief engineer, the party of the first part will pay to the party of the second part eighty per cent. of such estimated value, and whenever said contract shall be duly completed, in accordance with the terms herein contained, and in accordance with the specifications, and when said work and material shall be accepted by the chief engineer, for said party of the first part, a careful and detailed estimate shall be made of the value of all work and material furnished under said contract, and the amount due on said work shall be paid to said party of the second part, provided however it is not considered necessary by said first

party to retain a certain proportion of same as elsewhere provided for protection against claims for labor and material, for damages, for royalties or otherwise, and excepting also any amount retained as a guarantee for the maintenance of the work or material furnished under this contract, or for forfeiture."

B. Delayed Payments.

"In case any payment to the contractor on any estimate is delayed by the party of the first part beyond the time provided herein, said first party shall pay the contractor interest on the amount due at the rate of six per cent. per annum for the period of such delay. The term for which said interest shall be paid shall, in the case of progress estimates, date from the 10th day after the date of said estimate, to the date of payment of the estimate, and in the case of the final estimate from thirty days after the filing of the certificate of completion and acceptance to the date of final payment of the final estimate.

"If interest shall become due on any progress estimate, the amount thereof shall be added to the succeeding estimate; and if interest shall become due on the final estimate, it shall be added to such final estimate and paid therewith or by a special voucher within fourteen days thereafter. The contractor shall not be entitled to interest on any sum or sums which by the terms of this contract the party of the first part may be authorized to retain. It is hereby agreed that such interest payments, if any, are to be in lieu of any claims of the contractor for alleged damages, for breach of contract, or otherwise, on account of delayed payments."

C. Extra Work.

"All extra work done under this contract shall be paid for at actual cost plus fifteen per cent." (*Improper specification.*)

The above is quite a common form of specification for extra work, but is objectionable on account of its failure to define what is meant by "actual cost." The actual cost of a piece of work will of necessity include the cost of all material, labor and supplies furnished for the work in question. It includes also the cost of the time that any foreman may give to this special work. The work in general must be regarded as including not only the above items, but also the cost of general superintendence, office expenses in immediate connection with the work, timekeepers and other salaries and the cost, or at least the depreciation, on the tools and machinery used in connection with the same, also other general expenses. If the contractor is doing several pieces of work, each job must bear its portion of general expense of his main office, with traveling expenses to and from the work and even of other lettings. Unless these are included, plus a profit, the contractor would not be able to remain in business, for all the expenses named must be paid from the amount received for the work in question.

It is sometimes argued that extra work and its percentage of profit should be based not only on the items mentioned under actual cost, but also on the cost of general supervision or overhead charge and general expense or charge outside of the job.

When a contract job is taken, the items of general expense, overhead, etc., are necessarily calculated and apportioned among the various jobs of the contractor, and unless the total quantity of work to be done on some or all of these contracts has been materially reduced, an amount has been previously included sufficient to take care of these items. Hence, justice does not require that such items should be included in part of the cost of extra work unless the item of extra work is considerable and adds to such general expense. It may also be noted in this connection that, if overhead charges of a contractor's general office were to be considered as a part of the actual cost of the work under each individual contract, this might become burdensome in the event of the contractor's having, during a given time, only a single job to which all of such expenses would have to be charged. It therefore seems just to eliminate the general expense and overhead charge both of the contractor's general work and of the particular job in question, but to include all items which go to make up the actual cost of this work, whether ordinary or extraordinary, when incurred directly on account thereof. In general, this should include labor, material, supplies, immediate supervision, contractor's liability insurance, use and depreciation of small tools such as picks and shovels, and any other expenses directly incurred by or in consequence of the special work performed. Unless all of these are included, the ten or fifteen per cent. allowed to cover profit and general expense will be too small for the purpose, as insurance on certain classes of hazardous work may amount to several per cent. on the pay roll; and the cost of foreman, especially on difficult work, may sometimes be almost or quite as great as so-called profit allowed.

General expense also may frequently vary from as low as five per cent. to as high as ten per cent. of the contract price. It will be noted therefore that in order to be fair, all actual expenses directly connected with the work should be included, and a liberal percentage above this allowed for general expenses and profit.

In order that all extra work may be properly checked, it is desirable that the engineer should keep an account of the work performed and the material furnished for the same each day. If the work is simple a brief note or memorandum only will be necessary, but if at all

complicated it is desirable that the contractor be required to furnish a daily memorandum and a monthly bill of his charges on such amount.

"Extra Work: If during the performance of this contract the engineer shall order in writing other work done or materials furnished which in his opinion cannot be classified under the unit prices of this contract, the contractor shall do and perform such work and furnish such material and shall be paid therefor the actual cost thereof plus fifteen per cent. in addition thereto. The actual cost is hereby defined to include the cost of all labor and materials necessary for the performance of the extra work, including any extra expenses increased directly on account thereof, also the wages of foremen and the expenses attached to contractor's liability insurance covering the labor so employed.

"No allowance shall be made for overhead charges, general superintendence, general expenses, contingencies, or use and depreciation of the construction plant; neither shall said charges include the maintenance of the contractor's camp or office, unless such camp or office be maintained primarily on account of such extra work. The contractor shall submit to the engineer a monthly bill of all charges on account of such extra work, and if the engineer so desires shall also furnish a daily memorandum of all such charges."

When the extra work is of considerable magnitude the cost should include—

"also the pro rata wages of the Superintendent, General Foreman, Time Keepers and Material or Commissary Clerks."

If an expensive construction plant is to be used on such work provisions should be made to pay a certain sum for its use and depreciation, fixed either by an advanced agreement, a supplementary contract, or by arbitration. While 15 per cent. added for general expense and profit may be a fair compensation for extra work with small tools and when the plant investment is small it would be totally inadequate when machinery valued, perhaps, at from \$10,000 to \$25,000 is to be used. The use of such machinery should be covered by an allowance commensurate with the daily rental charge which would be made for such machinery on regular work. Where such use is to be anticipated a rental price may be fixed for such machinery in the itemized proposal.

D. Price for Work.—The prices bid by the contractor for the construction of work can be made a part of the contract by reference to the proposal which should be attached to the agreement or by re-writing the prices named in the bid directly in the agreement.

"In consideration of the furnishing of the material and the completion of all work by the said party of the second part, and on the completion of all work and of the delivery of all material embraced in this contract in

full conformity with the specifications and stipulations herein contained, the party of the first part agrees to pay the said party of the second part the prices set forth in the proposal hereto attached, marked 'Exhibit C,' which is hereby made a part of this contract. And the said party of the second part hereby agrees to receive such prices in full for furnishing all material and all labor required for the aforesaid work, also for all expense incurred by him, and for well and truly performing the same and the whole thereof in the manner and according to the specifications and requirements of the engineer.

"On the condition of the true and faithful performance of all the provisions in this agreement and in the specifications, the party of the first part agrees to pay to the said party of the second part the following sums, to wit: , in full payment for all work, material and supplies indicated in this contract embracing the complete and satisfactory construction of said work as defined and described in said specifications in all parts and requirements.'

E. Bond, Sureties and Special Guarantees.

(a) "*Bond:* It is further agreed by the parties to this contract that this contract shall be executed in triplicate, one copy being retained by the party of the first part, one to be delivered to the contractor, and one to the chief engineer. The party of the second part agrees to execute a bond for the sum of dollars for the satisfactory performance of the work in the form provided for that purpose, and it is agreed that this contract shall be void until such bond is furnished and approved by

(b) "*Sureties:* With the execution and delivery of this contract the contractor shall give security for the faithful performance of the contract by filing with the board one or more surety bonds in the form annexed hereto, the aggregate amount of which shall be not less than forty per cent. of the estimated total contract price. Each bond must be signed by the contractor and the sureties. The sureties, and the amount in which each will qualify, must be satisfactory to the board.

"Should any surety upon the contract be deemed unsatisfactory at any time by the board, notice will be given the contractor to that effect, and the contractor shall forthwith substitute a new surety or sureties satisfactory to the board. And no further payment shall be deemed due or shall be made under this contract until the new surety or sureties shall qualify and be accepted by the board.

"At the expiration of each year after the date of contract the liability of the sureties under the bonds may be reduced to that extent to which, in the opinion of the board, the need for surety is reduced, until such liability shall amount to twenty-five per cent of the original liability, at which amount the bonds shall remain in full force and virtue until the completion of the entire work."

F. Guarantees, Bonds, or Per Cent. Retained.—Guarantees made for maintaining the work or operating the plant for a definite period are generally protected either by a bond or by the retention of a percentage of the contract price.

"The said contractor further agrees that the said city shall be and is hereby authorized to retain out of the money payable to the contractor under this agreement, the sum of five per cent. of the amount of this contract and to expend the same in the manner hereinafter provided for in making such repairs on the line of said work as the engineer may deem necessary. The said contractor further agrees that if, at any time during a period of six months from the date of the final completion of the work contemplated in this contract, any part of said work shall, in the opinion of the said engineer require repairing, and said engineer shall notify the contractor in person or by mail to make the repairs so required, and that if the said contractor shall neglect to make such repairs, to the satisfaction of the said engineer, within three days after giving or mailing such notice to the said contractor, his agent or attorney, then the said engineer shall have the right to employ such other person or persons as may be deemed proper to make the change; and the said party of the first part shall pay the expense thereof, out of the sum retained for the purpose, by it, as before mentioned. And the said city further agrees upon the expiration of the said period of six months, provided that the said work shall at that time be in good order, that the said contractor shall be entitled to receive the whole or such part of the sum last aforesaid as may remain after the expense of making said repairs in the manner aforesaid shall have been paid therefrom."

§ 152. **Form of Bond.**—The following form of bond has been adopted by the Board of Directors of the Miami Conservancy District in connection with the extensive flood protection work which is soon to be undertaken along the Miami River.*

BOND

Know all men by these presents, that we, ..., ..., of, County of and State of, as Principal, hereinafter called the Contractor, and, ..., organized under the laws of the State of and duly authorized to transact business within the State of Ohio, as Surety, hereinafter called the Surety, are held and firmly bound unto THE MIAMI CONSERVANCY DISTRICT, a corporation organized under the laws of the State of Ohio, with its principal place of business located at Dayton, County of Montgomery, and State of Ohio, as Obligee, hereinafter called the District, in the sum of dollars (\$..) lawful money of the United States, for the payment whereof to the District the Contractor binds, ..., heirs, executors, administrators, successors, and assigns, and the Surety binds itself, its successors, and assigns, firmly by these presents.

* See Report of A. E. Morgan, Chief Engineer, Vol. III, p. 17.

Whereas, the Contractor and the District have entered into a written contract, dated the day of 191., hereinafter called the *Contract*, a copy of which is attached hereto and made a part hereof, for

The condition of this obligation is such that if the said Contractor shall pay all persons, firms or corporations who perform labor or furnish equipment, supplies and materials for use in the work thereunder, and shall satisfy all claims against the district, for damages to life, limb or property that may be caused by the acts of, or negligence of, the Contractor or any of his agents or employees, and shall satisfy all suits or claims brought against the District arising from the violation of any law, ordinance, regulation, order or decree on the part of the Contractor or any of his agents or employees; or from any infringement, or alleged infringement of patents in the work under said Contract; or howsoever originating from any of the operations under said Contract; and shall fully indemnify and save harmless the District from all cost and damage which it may suffer by reason of failure so to do, and shall fully reimburse and repay the district all outlay and expense which the District may incur in making good any such default, and in all other particulars shall faithfully perform the contract on his part according to all the terms, covenants, and conditions thereof and within the time specified therein, then this obligation shall be void; otherwise to remain in full force and effect.

Provided,

First—That should the Contractor fail to comply with the provisions of the Contract to such an extent that the Contract shall be forfeited, the Surety shall have the right to assume the Contract and proceed to perform or sublet the same, as therein provided. And the Surety shall, in that event, be subrogated to all the rights and interests of the Contractor arising out of the Contract, and be entitled to hold and use all of the equipment and properties of the Contractor which may be necessary for the completion of the Contract; and all moneys which may be due the Contractor at the time of his default or which may thereafter become due said Contractor, under or by virtue of the Contract, shall become due and payable to the Surety as the work progresses, subject to all of the terms of the Contract.

Second—That any alterations which may be made in the terms of the Contract, or in the work or materials to be furnished thereunder; or the granting by the District of any extension of time; or any forbearance or action on the part of either the District or the Contractor

toward the other under said Contract ; shall not in any way release the Contractor and the Surety, or either of them, their heirs, executors, administrators, successors, or assigns, from their liability hereunder ; notice to the Surety of any such alteration, extension, forbearance, or action, being hereby waived ; provided that the written consent of the Surety shall first be obtained if any alteration be required which shall alter the general character of the work as a whole, or which shall increase the total amount to be paid to the Contractor by more than 25 per cent.

Third—No right of action shall accrue hereunder to or for the use or benefit of any one other than the District, and the District's rights hereunder may not be assigned without the written consent of the Surety.

Signed and sealed, this day of, 19...

Witnesses :

..... [Seal.]
..... [Seal.]
..... [Seal.]
Principal.

[Seal]

.....
.....
.....
President.
SURETY.

Attest :
.....
Secretary.

§ 153. Responsibility of Contractor as Affecting Party of the First Part.—Contracts for work or for furnishing material, etc., are usually entered into on account of the familiarity and equipment of the contractor which will enable him to do the work of this class to advantage, and in order that the party of the first part may have the work done without personal responsibility either as to the operations of construction or the ultimate results of the work. In order that the contractor may be required to assume these responsibilities, various stipulations are necessary, and such responsibilities must be stipulated in detail, and great care must be exercised on the part of the engineer to see that all such matters be fully covered.

A. Persons Interested in Contract.

"No person or persons other than whose name.. affixed hereto as part.. of the second part now ha.. any interest hereunder as contractor... This contract shall be void if any member of the board or other officer of the city of or any person in the employ of said board or said city is or shall become directly or indirectly interested as contracting party, partner, stockholder, surety or otherwise in the performance of this contract or in the supplies, work or business to which it relates or in any portion of profits thereof. Provided that incidental interest such as the ownership of stock or bonds in a railroad, telephone or other public utility, which may as an incident to its usual business furnish services or supplies to the contractor, shall not be included in the meaning of this provision."

B. Personal Attention of Contractor.

"The contractor shall give personal attention to the faithful prosecution and completion of this work and shall be present either in person or by duly authorized representative on the site of the work continually during its progress. He shall maintain an office on or adjacent to the site of the work."

C. Contractor's Address.

"Both the address given in the proposal upon which this contract is based and the contractor's office at or near the site of the work are hereby designated as places to either of which notices, letters or other communications to the contractor may be mailed or delivered. The delivering at either of the above named places of any such notice, letter, or other communication from the party of the first part to the contractor shall be deemed sufficient services thereof upon the contract, and date of said services shall be the date of such delivery."

D. Contractor's Agent.—To avoid the assumption of personal responsibility by the party of the first part, the right to direct individual workman should not be reserved. Such instructions as may be necessary must be given only to the contractor or to his duly authorized agent, and to assure the constant attendance of some duly authorized agent of the contractor, during the progress of the work, requires a specific clause in the agreement.

"The contractor, during his absence from the work, shall keep a competent superintendent or foreman upon the work, fully authorized to act for him in his absence, and to receive such orders as may be given for the proper continuance of the work. Notice of any imperfections in the work or material furnished to any foreman or agent in charge of any portion of the same, in the absence of the contractor, shall be considered as notice to the contractor."

E. Observance of Laws and Ordinances.—When an agreement is made, especially by a municipal corporation, for work to be done in city streets, or when the public may become interested or affected, a

stipulation should be included binding the contractor to observe the laws and ordinances so that he may claim no exemption on account of the provision of the agreement.

"The party of the second part shall be subject to all laws and ordinances of the city of, ..., within which city this agreement is to be fulfilled, and said contractor shall be entitled to no exemption therefrom on account of this contract."

F. Protection Against Negligence and Damages.—In every agreement stipulation should be included providing for the protection of public property, and the liability of the contractor should be fixed for any negligence of himself or of his employees and for resulting damage occasioned thereby.

"Should any work be done or material furnished or placed on the public steets or ways or in any other place where protection is necessary, the contractor shall, at all times, and especially during the night, put up and maintain such barriers and red lights and take such other needful precautions as may be necessary to effectually prevent the happening of any accidents in consequence of the work being done or material being deposited in such places, and the contractor shall be liable for all damages occasioned in this way or by reason of his act or neglect or of that of any authorized sub-contractor or any agent, employee or workmen; and the said contractor shall save and keep harmless the said first party from all suits or demands for damages alleged to have occurred to persons or property by reason of said work or of so placing said material or from said act or negligence.

"And the said party of the second part further agrees during the performance of the work to take all necessary precaution and to place proper guards for the prevention of accidents and put up at night suitable and sufficient light and will indemnify and save harmless the said parties of the first part from all damages and costs to which they may be put by reason of injury to the person or property of another, resulting from negligence or carelessness in the performance of the work or in guarding the same, or from any improper material used in its construction, or by or on account of act or omission of the said party of the second part or the agent thereof; and the said party of the second part hereby further agrees that the whole or so much of the money due under or by virtue of this agreement as shall or may be considered necessary by the aqueduct commissioners shall, or may be, retained by the parties of the first part until all suits or claims for damages, as aforesaid, have been settled and satisfactory evidence to that effect furnished the said commissioners.

"The said contractor shall take proper means to protect the adjacent or adjoining property or properties in any way encountered or which might be injured by any process of construction, to be undertaken under this agreement, and he shall be liable for any or all claims for damages on account of his failure to fully protect all property injured during or on account of such construction."

G. Protection Against Claims for Labor and Material.—The agreement should contain stipulations protecting the party of the first part from all claims for labor and material furnished for the completion of the contract, and it should also contain any special restriction necessary for the method of paying labor on the work.

“The said party of the second part agrees that he will indemnify and save harmless the party of the first part from all claims against said first party for material furnished or work done under this contract, and it is further agreed by the party of the second part that said second party shall if so desired furnish the said first party satisfactory evidence that all persons who have done work or furnished material under this agreement have been duly paid for such work or material, and in case such evidence is demanded and not furnished to the aforesaid first party, such amount as may, in the opinion of the said first party, be necessary to meet the claims of the persons aforesaid, may be retained from the money due said party of the second part under this agreement, until satisfactory evidence be furnished that all liabilities have been fully discharged.”

H. Protection Against Royalties on Patented Inventions.—The party letting the work should commonly be protected from suit for damages occasioned by the use of patented articles on or in connection with the work or the installation included in the contract. A stipulation should therefore be included in the specifications by which the contractor agrees to protect the party of the first part from any and all royalties on any patented invention installed or used by him in connection with the work, or if the said party of the first part is to pay for such royalties it should be so provided and specified. Such stipulations should especially be provided in the agreement covering installation of machinery or in the installation of various works for manufacturing or similar installation. The contractor should not, however, be held for the use of patented articles or methods which are specified in the contract, but arrangements for the use of such patents should be made by the engineer or other agent of the party of the first part.

“The contractor shall protect and save harmless the party of the first part from all and every demand for damages, royalties or fees on any patented invention used by him or used in connection with the work done or material furnished under this contract, and it shall be the duty of such contractor if so demanded by the party of the first part to furnish said first party with a proper legal release or indemnity from and against all such claims, and any or all payments may be withheld from said contractor until said release is furnished if the party of the first part so elects. The above shall not, however, include any patented invention or process ordered by the engineer or specified in the contract.”

I. Assignment and Subletting.—In cases where the agreement is drawn for the personal skill or professional knowledge of the contractor, no assignment or subletting of the work would naturally be permitted. In other cases, it is usually desirable that the assignment or subletting of the work, or any part thereof, shall be done only with the knowledge and consent of the parties of the first part or their duly authorized agents. It is therefore customary to include in the agreement some clause, stipulating such restrictions in regard to this matter as the conditions may make desirable.

“The said contractor further agrees that he will give his personal attention to the fulfillment of this agreement and that he will not sublet the aforesaid work or the furnishing of the aforesaid material, but will keep the same under his personal control, and that he will not assign by power of attorney or otherwise any portion of said contract unless by and with the previous consent of the first party as signified by endorsement of this agreement by the officials whose signatures are attached hereto.

J. Abandonment and Forfeiture.—In order to provide for due progress on the work under the conditions of abandonment of the same by the contractor, it is customary to introduce a stipulation whereby the parties of the first part may, after due notification to the contractor's sureties, carry the work to completion.

“In case the contractor shall abandon the work and fail or refuse to commence it again within days after notification from the first party, or if he should fail to comply with the orders of the engineer or with this agreement or with the specifications hereto attached, then, and in that case, the sureties on the bond shall be notified and directed to complete the same. In case the sureties fail to comply with the notice, the first party may, within days after serving such notice, carry on the work at the expense of the contractor and sureties.”

In the flood protection work of the Miami Conservancy District where large and important contracts are involved and where the matter of delays may become serious, a more elaborate provision for terminating the contract has been prepared after serious and thorough consideration.*

“If the work to be done under this Contract shall be abandoned by the Contractor, or if this Contract shall be assigned, or placed in bankruptcy, or the work sublet by him, otherwise than as herein specified, or if at any time the Engineer shall be of the opinion, and shall so certify in writing to the Board, that the performance of the Contract is unnecessarily or unreasonably delayed, or that the Contractor is violating any of the conditions or agreements of this Contract, or is executing the same in bad faith or not in accord-

* Report of A. E. Morgan, Chief Engineer, Vol. III, p. 44.

ance with the terms thereof, or is not making such progress in the execution of the work as to indicate its completion within the time specified in this Contract, or within the time to which the completion of the Contract may have been extended by the Board, the Board may notify the Contractor to discontinue all work or any part thereof, under this Contract, by a written notice to be served upon the Contractor as hereinbefore provided, and a copy of which notice shall be given to his Surety, or the authorized agent for the latter; thereupon the Contractor shall discontinue the work, or such part thereof as the Board shall designate, and thereupon, the Surety may, at its option, assume this Contract, or that portion thereof on which the Board has ordered the Contractor to discontinue work, and proceed to perform the same, and may, with the written consent of the Board, sublet the work or portion of the work so taken over; provided, however, that the Surety shall exercise its option, if at all, within two weeks after written notice to discontinue work has been served upon the Contractor and upon the Surety or its authorized agent. The Surety, in such event, shall take the Contractor's place in all respects, and shall be paid by the party of the first part for all work performed by it in accordance with the terms of this contract; and if the Surety under the provisions hereof shall assume said entire Contract, all moneys remaining due the Contractor at the time of his default, shall thereupon become due and payable to the Surety as the work progresses, subject to all of the terms of this Contract.

In case the Surety does not, within the hereinbefore specified time, exercise its right and option to assume this Contract or that portion thereof on which the Board has ordered the Contractor to discontinue work, then the Board shall have the power to complete by contract or otherwise, as it may determine, the work herein described, or such part thereof as it may deem necessary, and the Contractor agrees that the Board shall have the right to take possession of and use any of the materials, plant, tools, equipment, supplies and property of every kind provided by the Contractor for the purpose of his work, and to procure other tools, equipment and materials for the completion of the same, and to charge to the Contractor the expense of said contracts, labor, materials, tools and equipment and expenses incident thereto. The expense so charged shall be deducted by the District out of such moneys as may be due or may at any time thereafter become due the Contractor under and by virtue of this Contract, or any part thereof. The Board shall not be required to obtain the lowest figures for the work of completing the Contract, but the expense to be deducted shall be the actual cost of such work. In case such expense is less than the sum which would have been payable under this Contract if the same had been completed by the Contractor, then the Contractor shall be entitled to receive the difference; and in case such expense shall exceed the amount which would have been payable under the Contract if the same had been completed by the Contractor, then the Contractor shall pay the amount of such excess to the District on notice from the Board of the excess so due; but such excess shall not exceed the amount due, under this Contract, at the time the Contractor is notified to discontinue said work, or any part thereof, plus the amount of the bond or bonds executed by the

Contractor for the performance of this Contract. When any particular part of the work is being carried on by the Board, by contract or otherwise, under the provisions of this section, the Contractor shall continue the remainder of the work in conformity with the terms of this Contract, and in such manner as in nowise to hinder or interfere with the persons or workmen employed, as above provided, by the Board."

K. Time and Order of Completion—Liquidated Damages—Right to Discontinue Work.—The time of completion of a contract is often of great importance, and in all contracts, even where the importance of early completion is not great, a time of completion should be specified, otherwise the work may be delayed unduly.

The time of completion must often be made the essence of a contract on account of:

(a) The necessity of having a given work completed to meet certain emergencies, contingencies or uses.

(b) On account of the losses of interest on investment or other damages which may be occasioned by delay.

For these reasons, and perhaps for many others which might be mentioned, a specific time of completion should be stipulated in the agreement. It is also frequently desirable that certain portions of the work shall be completed first, and that other portions of the work shall follow in a given order, to best serve the purposes of the construction. In such cases, the order of completion may be an essential feature of an agreement. The character of the work may also be such that it cannot be properly performed under certain weather conditions, and it may become desirable to discontinue the work when such conditions arise. When such conditions are likely to arise, stipulations to this effect should be included in the agreement.

There can be no doubt that a contractor is legally bound by a stipulation to complete a contract on a given day or date provided the time limit is reasonably possible, and provided also that he is not delayed by conditions entirely beyond his control. When a contractor delays the time of completion beyond that specified in the contract, and especially when such delays are caused by his own negligence, he is undoubtedly liable for damages occasioned by such delays, and such damages can be collected by due process of law.

"The party of the second part further agrees that the work shall be commenced and carried on at the point and in the order of precedence specified.

"The said party of the second part further agrees that he will commence the work within days after the execution of this contract, and will

progress therewith so that by the day of, 19..., the work shall be completed in accordance with this agreement."

L. Rate of Progress and Forfeiture.—When the time of completion is important, and the length of time necessary for construction is considerable, it is not sufficient simply to provide that the work shall be completed at a certain date, for with such a provision no recourse can be had against the contractor until after the date of completion. To assure the prompt completion of the work, it is desirable in all such agreements to stipulate that the rate of progress shall be made an essential feature of the contract, and it should be provided that unless the rate of progress necessary to complete the work in the specified time is maintained, the contract may be forfeited and relet, or the work prosecuted by other means, which means should be specified in detail.

Failure to maintain a given rate of progress and the consequent forfeiture of a contract are serious features when forfeiture is actually declared, and are apt to lead to litigation. For this reason, the method of determining progress should be clearly defined, so that the right to declare forfeiture in case forfeiture is declared, may be perfectly clear.

The fundamental basis on which the rate of progress and completion of all contracts must depend, is the number of days' work to be done, and the time available for doing it. Under ordinary conditions, the rule for determining the rate of progress is to first determine the total number of days worked included in all classes of work covered by the contract, and divide by the time. The quotient will be the number of days' work which must be done in each unit or division of time. The factors in the problem are the quantity of work, and the time in which it is to be done; and the ordinary and usual method of calculating the quantity of work is by the day's work.

The term "day's work" represents the amount of work which can be done by one man in one day, and is independent of the pay which the man receives: thus, a laborer at \$1.75 per day, a stone-cutter at \$6.00 per day, or a sculptor at \$50.00 per day would each do one day's work in one day's time. The cost, therefore, is not the measure of quantity of work, although it is the measure of value.

In all contracts, however, where one class of work only is involved, or where the classes are so similar that the cost of the same is in proportion to the work done, quantity and values are essentially similar, and the rate of progress may be measured by either quantity or value. From the inception of the work, the engineer must bear in mind the time required for its completion, and the rate of progress must be based

upon the actual time which will be required for completion. Often on account of the nature of certain portions of the work, a greater portion of time must be allowed for the execution of certain classes of work, and on others on account of limited space or other conditions where only a certain number of days' work per day are possible. Frequently correlative work, or work which depends for its execution on the completion or progress of other work, will take no especial or distinct portion of time for its execution, as it can progress as other work progresses.

In the practical execution of work, another feature must be considered in this connection, that is, the preparation for the execution of work. It takes a certain length of time to get the plant on the ground, and to get it in shape for the proper performance of its functions. Then, too, in the beginning of a work it is impossible to accomplish as much the first month as the second, or the second month as the fourth, but a considerable time must elapse before the work is in full swing and can be systematically prosecuted. This is due to the fact that men and machinery are new and also to the fact that work cannot be well prosecuted until it is opened up and rendered accessible.

Rate of progress also depends on the plant installed, and the specifications requiring a higher rate of progress may involve an expenditure for a plant which will add materially to the cost of the work. The plant must necessarily be selected in view of the time of completion and the rate of progress required; thus, a single steam shovel will handle from 600 to 1,000 yards of earth per day and cannot be set up to advantage for removing less than 100,000 yards. If the rate of progress specified is so great that a large number of shovels are required, the investment involved is very large, and the cost per yard may be greatly increased over what the cost would be if sufficient time were allowed so that only one shovel would be required.

A high rate of progress of work is often possible where it is not feasible, for the element of cost is important not only to the contractor who takes the work, but also to the party having the work done, for the contractor must base his charges on the absolute requirements of construction.

The specifications of the Sanitary District of Chicago, provide:

"The work done each month shall not be less than the proportion indicated by the total number of months, provided that the first four months after notice to begin shall be considered as one month and the last two months before completion as one month, and provided further that this rate shall not be required if at any time the aggregate work done exceeds the total proportion due to the time that has passed since notice to begin work,

and always provided that the sanitary district shall not be obliged to make payment in excess of the above month in proportion."

The Aqueduct Commission of the City of New York, in a contract for Section 13 of the New Croton Aqueduct required:

"That the rate of progress shall be such that, 1st, in 100 days from the execution of the contract both the shafts shall be excavated to their full depth; 2d, in each and every month, commencing 60 days from the time the shafts must be excavated, not less than one-ninth of the total length of each heading shall be excavated; 3d, on or before the 30th day of September, 1887, the whole work shall be completed in accordance with this agreement."

In a contract for the improved sewerage of the City of Lynn, Massachusetts, the requirement for time of beginning, rate of progress, and time of completion, are as follows:

"The said contractor further agrees that he will commence the work within ten days of the execution of the contract and will progress there, with so that by the 20th day of October, 1887, the value of the work done, and the materials delivered shall at least equal one-third of the value of the total amount of work to be done and the materials to be delivered under this contract and by the 15th of November, 1887, said value shall at least equal one-half of said total amount, and by the first of July, 1888, the whole work shall be completed in accordance with this agreement."

This last specification includes work in which the amount of work and material is fairly measured by the value of said work and material. In many contracts this is frequently not the case. For example, in works for construction of levees, which require the clearing and grubbing of land and in which the price for said clearing and grubbing is included in the price per cubic yard for the levees, the cost of the preliminary work may be very considerable and may require a considerable amount of labor and time, for which, in the contract, no direct return is received, and an allowance for time must necessarily be made for the execution of these preliminary works.

It has been suggested by Mr. E. R. Shnable that a satisfactory method of handling the rate of progress would be to provide a blank in the proposal, and require the contractor to fix his own rate of progress in percentages, essentially as follows:

"If awarded the contract for this work propose to complete the same at the rates indicated in the following table in which the progress is expressed in percentages of the money value of the work to be performed under the contract, at the various dates specified.

On October 1, 1916..... per cent.	On February 1, 1917..... per cent.
On November 1, 1916..... per cent.	On March 1, 1917..... per cent.
On December 1, 1916..... per cent.	On April 1, 1917..... per cent.
On January 1, 1917..... per cent.	On May 1, 1917..... 100 per cent.

May 1st being the date of completion fixed by the specifications or otherwise.

M. Liquidated Damages.—Liquidated damages to the extent of the actual damages occasioned by the delay will undoubtedly constitute a legal and valid claim. The agreement may fix a certain sum as damages for delay, but there is always a question as to whether the amount fixed may be actually retained or recovered at law. While it is a common practice in such stipulations to define the sum to be retained as “liquidated damages,” it is nevertheless true that the court will usually not regard such sum as actual. “liquidated damages,” unless it can be shown that the actual damages sustained were equal to or greater than the amount as named. In such cases the court will not sustain a penalty but will sustain the collection or retention of the actual damage when said damage is not less than the amounts named in the contract.¹⁵

It may here be noted that difficulties in the way of construction, casualties, accidents, etc., are not excuses which will tend to relieve the contractor from “liquidated damages.” On the other hand, a delay occasioned by the party of the first part or by other contractors may relieve a contractor from “liquidated damages.”¹⁶ When liquidated damages are actually incurred, such damages are sometimes waived by a failure to notice the default or by allowing the work to continue and payments to be made as if such default had not occurred.¹⁷

Where the time of completion is a matter of real moment and “liquidated damages” are specified for delays, it is desirable in the interest of fairness and justice to also insert a bonus clause for the completion of the work in advance of the time requirement. The bonus clause also adds the element of mutuality and assures the enforcement of either penalty or bonus as a matter of mutual agreement.

“Should the contractor fail to complete the work as herein specified within the time named, unless granted an extension of time by the party of the first part, he shall be liable for the wages of the superintendent on his work from the above specified time to the date of the engineer’s certificate of completion of his work, and the amount of such wages shall be deducted from the money which may be due to him from the amount of the final estimate, or if no monies shall be due him from the party of the first part, then the amount shall be recoverable from the contractor or his surety.

“The said contractor hereby further agrees that the said shall be and is hereby authorized to deduct and retain out of any money

¹⁵ Wait, Engineering and Architectural Jurisprudence, secs. 315 to 320.

¹⁶ Ibid, secs. 324 and 326.

¹⁷ Wait, Engineering and Architectural Jurisprudence. Sec. 325.

which may be due or become due to the said contractor, under this agreement, the sum of dollars (\$..) per day as liquidated damages for every day the aforesaid work may be uncompleted over and beyond the time herein stipulated for its completion: provided, however, that the said first party shall have the right to extend the time for the completion of the said work if he should decide so to do.

"And the said party of the second part agrees to commence the work herein required to be done within days after the signing of this contract, and that the rate of progress shall be such that on or before the day of, 19.., the whole works shall be completed according to this agreement.

"In case the said party shall fail to fully and entirely, and in conformity with the provisions and conditions of this agreement, perform and complete the said work and each and every part and appurtenances thereof within the time hereinbefore specified for such performance and completion, or within the said further time which may be allowed by for such performance and completion, the said party of the second part shall and will pay to the said party of the first part the sum of (\$..) for each and every day that the said party of the second part shall be in default, which said sum of (\$..) per day is hereby agreed upon and determined by the parties hereto as the damages which the party of the first part will suffer by reason of such default and not by way of penalty, and the said parties of the first part may deduct and retain the said sum of (\$..) per day out of any money which may be due or become due under this agreement."

"The time of completion is of great importance, and it is mutually agreed between the parties to this contract, that in case said party of the second part shall fail to fully and entirely perform and complete the said work and every part thereof, in full conformity with the provisions and conditions of this agreement, and within the time herein before specified for such performance and completion, then, and in that event, the said party of the second part shall and will pay to the said party of the first part the sum of (\$..) for each and every day that said work shall remain uncompleted. In event, however, that said work shall be fully completed before the date specified for such completion, then and in that event, the said party of the first part shall and will pay to the said party of the second part, the sum of (\$..) for each and every day that the said party of the second part shall have completed the contract in advance of the time of completion specified. The said party of the first part may deduct and retain the said sum of (\$..) per day for each day of delay beyond the date of completion specified, out of any moneys which may be due or become due under this agreement, or shall add to the final payment of the party of the second part, the sum of (\$..) for each day the work is completed prior to the specified date of completion."

§ 154. Conduct of the Work.

A. Keeping of Plans and Specifications Accessible.—It is usually desirable to have plans and specifications readily accessible on the work,

in order that the requirements of the contract can be discussed and defined by the engineer or inspector with the contractor and his superintendent. These papers can usually be made most conveniently accessible by being kept at the contractor's local office or in some other manner on the work. A clause to this effect is commonly desirable.

"The contractor shall keep a copy of the plans, profiles and specifications constantly accessible on the work for the use of the engineer and inspector in the work of supervision. The party of the first part shall, however, furnish free of charge, such plans, profiles and specifications as are necessary for this purpose."

B. Character of Workmen.—(Foreign labor, convict labor and eight-hour law.) While the party of the first part, if he would place the responsibility as to accidents and ultimate results on the contractor, must not undertake the direction of individual workmen, he may provide that such workmen shall be faithful, orderly, competent and skillful. Where work is to be done for the public, or must be done under any statutory enactments, it is desirable also to include a stipulation reciting the restrictions of such statutes.

"The said party of the second part agrees to employ only orderly, competent and skillful men to do the work; and that whenever the engineer shall inform him in writing that any man or men on the work are, in his opinion, incompetent, unfaithful or disorderly, such man or men shall be discharged from the work and shall not again be employed on the same without the engineer's written consent."

The following extract from one of the specifications of the United States' Reclamation Service is an example of the restrictions which it may be necessary to introduce in certain contracts:

"In all construction work eight hours shall constitute a day's work and no Mongolian labor shall be employed thereon. The importation of foreigners and laborers under contract to perform labor in the United States or the Territories or the District of Columbia is prohibited. (Sec. 3738, Rev. Stat. U. S. Acts: Aug. 1, 1892, 27 Stat. L., 340; June 17, 1902, Sec. 4, 32 Stat. L., 388; Feb. 26, 1885, 23 Stat. L., 332; and Feb. 23, 1887, 24 Stat. L., 414.) In the performance of this contract no persons shall be employed who are undergoing sentences of imprisonment at hard labor imposed by courts of the several States, Territories or municipalities having criminal jurisdiction. (Executive order, May 18, 1905.)"

C. Losses and Damages.—It is also desirable that a clear understanding shall exist as to who is to bear the expense due to casualties or to losses due to the action of the elements or expenses incurred from other unforeseen conditions or contingencies which may increase the cost of the work. These conditions are usually controlled to a greater

or less extent by the skill, care and methods used by the contractor. For this reason he is usually required to bear the expense of the same.

"All loss or damage arising out of the nature of the work to be done or from the action of the elements or from any unforeseen circumstances in the prosecution of the same or from unusual obstructions or difficulties which may be encountered in the prosecution of the work, or from any casualty whatsoever of every description, shall be sustained and borne by the contractor at his own cost and expense."

D. Protection of Finished or Partially Finished Work.—It is commonly desirable for the liability for the care of wholly or partially finished work to remain in the contractor until the entire completion of the contract, and he shall not be relieved in this matter on account of estimates or payments made on such work.

"The contractor shall take all necessary precautions to protect all work done, or material furnished under this agreement, from injury by action of the elements or by the process of construction; he shall also take proper means to protect adjacent or adjoining property or property in any way encountered or which might be injured by the process of construction to be taken under this agreement."

"The contractor shall properly guard and protect all finished or partially finished work, and shall be responsible for the same until the entire contract is completed and accepted by the engineer. Estimate of partial payment on work so completed shall not release the said contractor from such responsibility but he shall turn over the entire work in full accordance with the specifications before final settlement shall be made."

"The contractor shall take all necessary precautions to protect all work done or material furnished under this agreement from injury by the action of the elements or the processes of construction, and on completion of the contract shall turn over the same and every part thereof in full accordance with these specifications."

E. Hindrances and Delays.—Various unexpected hindrances and delays during the process of construction may add considerable to the expense of the work. The contractor is commonly required to sustain such extra expense without extra compensation. In writing such stipulation, care must be exercised to see that no injustice or unnecessary hardship is placed on the contractor.

When the progress of work is delayed from causes entirely beyond the control of the contractor, he is ordinarily entitled to an extension of time. In order to secure such extension, he is usually required to make an application in which he must set forth the causes of the delay.

In granting such extensions of time it is usually desirable and customary to first secure the consent of the sureties on the contractor's bond, after which the contractor should be notified of the extension

granted. It should also be stipulated that, in granting such extension of time, the party of the first part does not otherwise waive any rights under the contract.

"No charge shall be made by the contractor for hindrances or delays from any cause (except where work is stopped by order of the parties of the first part) during the progress of any portion of the work embraced in this contract, but such delays, if due to no fault or neglect of the contractor, shall entitle him to an extension of time, allowed for completing the work, sufficient to compensate for the detention, provided the contractor shall give the engineer immediate notice in writing of the cause of such detention. The amount of the detention shall be determined by the engineer, and the extension of time shall not include unseasonable weather. In case said work shall be stopped by the act of the party of the first part, then such expense as in the judgment of the engineer is caused by such stopping of said work, other than the legal cost of carrying on the contract, shall be paid by the party of the first part to the party of the second part.

"The reserve the right of suspending the whole or any part of the work contracted to be done when they shall deem it for the interests of the City of so to do, without compensation for loss to the contractor for such suspension other than extending the time of completing the work as much as it may have been delayed by such suspension; and if the said work shall be delayed for the reason that the parties of the first part do not own or have not obtained possession of land on which same is to be performed, then and in that case and every such case, the party of the second part shall be entitled to so much additional time wherein to perform and complete this contract on his part as the engineer shall certify in writing to be just, but no allowance by way of damages shall be made for such delay. Neither an extension of time for any reason beyond that fixed herein for the completion nor the doing and acceptance of any part of the work called for by this contract, shall be deemed to be a waiver by the said commissioners of the right to abrogate this contract for abandonment or delay, in the manner provided for in the paragraph marked in this agreement."

F. Defects, and Their Remedies.—(Work and material.) Work and material furnished on a contract must be fully in accordance with the agreement and specifications. Work that has been done and is not of the quality required by a reasonable interpretation of the specifications should be torn down or removed and rebuilt in accordance with the requirements. If the materials when brought on the site of the work are not found satisfactory and in full accordance with the agreement and specifications, they should be removed at once so that they may not be used in the work either by mistake or when the engineer is not aware of such use. A stipulation to this effect in the agreement is therefore advisable.

"And it is further agreed that if the work or any part thereof, or any material brought on the ground for use in the work, or selected for the same, shall be deemed by the engineer as unsuitable, or not in conformity with the specifications, the contractor shall forthwith remove such material and rebuild or otherwise remedy such work in accordance with the directions of the engineer."

G. Construction Plant.—Agreements are usually made with contractors for certain classes of work on account of their experience in such work and on account of their possession of necessary tools, machinery and plant for the construction of the work in question. The agreement should therefore include a stipulation providing that the contractor shall furnish the necessary tools, machinery, equipment and plant for the construction of the work to be done under the agreement, unless such tools, machinery, equipment, and plant are to be furnished by the party of the first part.

"The party of the second part shall provide all labor, tools and machinery and material necessary in the prosecution and completion of this contract where it is not otherwise specially provided that the party of the first part shall furnish the same, and it is also to be understood that the party of the first part shall not be held responsible for the care or protection of any material, tools or machinery or for any part of the work until it is finally completed and accepted.

"The said contractor shall furnish the necessary scaffolding, ways and all necessary means and conveniences for the transfer of the material to its proper place, and for its erection; and it is also to be understood that the party of the first part shall not be held responsible for the care or protection of any material or part of the work until its final acceptance."

§ 155. **Police and Sanitary Regulations.**—Certain restrictions are usually desirable in order to enforce satisfactory police and sanitary conditions and to prevent trouble from the use of intoxicants on the work. The latter is especially essential when the work to be done is isolated from communities where liquor is sold under license.

Only three brief specifications of a general nature are here given as examples. It is frequently necessary to make exact regulations which will cause the contractor considerable expense, especially where large works are to be constructed in connection with the water supplies of large cities. In such cases the specifications should be fully elaborated in order that the contractor may be completely informed as to the expense which will be involved because of the sanitary regulations.

A. Sanitation.

"Necessary sanitary conveniences for the use of laborers on the work, properly secluded from public observation, shall be constructed and main-

tained by the contractor in such manner and at such points as shall be approved by the engineer, and their use shall be strictly enforced.

B. Intoxicants.

"The contractor shall neither permit nor suffer the introduction or use of spirituous liquors upon or about the works embraced in this contract or upon any grounds occupied by him.

C. Contractor's Buildings.

"The building of structures for housing men, or the erection of tents or other forms of protection will be permitted only at such places as the engineer shall provide, and the sanitary condition of the grounds in or about such structures shall at all times be maintained in a manner satisfactory to the engineer."

LITERATURE

Engineering and Architectural Jurisprudence. John C. Wait. Part III. A construction contract. John Wiley & Sons, Inc. New York.

Engineering Contracts and Specifications. Prof. J. B. Johnson. Including discussions of the general clauses of contracts and specifications. 3d ed. McGraw-Hill Book Co. Inc. New York.

The Standard Documents of the American Institute of Architects. Containing contract forms and general condition of the contract as recommended by the Institute. Published by the Institute at Washington, D. C.

Elements of Specifications Writing. Prof. R. D. Kirby. Discussion advertisements, proposals, contracts, general conditions and specific clauses in contracts. John Wiley & Sons, Inc. New York.

Laws and Business of Engineering and Contracting. C. E. Fowler. Discussion contracts and specifications. The relation of the engineer and contractor. Inspection, contracting, bidding, organization of contract work, etc. McGraw-Hill Book Co. Inc. New York.

Specifications and Contracts. J. A. L. Waddell and John C. Wait. Discussion of contract and specification writing. Engineering contracts and contract law. McGraw-Hill Book Co. Inc. New York.

The Principles of Specification and Agreement Writing. C. R. Young. Pamphlet published by the Canadian Engineer. Toronto, Canada.

Civil Engineering Specifications and Contracts. R. I. D. Ashbridge. American Technical Society. Chicago.

Engineering Contracts. Lecture on general subject, with examples by J. A. L. Waddell to students in several universities. Published by the author.

Unreasonable Contract Requirements by the Government. Discusses lack of explicitness and disadvantage of lump sum method of doing work for the Charleston dry dock. Gives extracts from Specifications—Staff article. Eng. Rec. Vol. 46, pp. 265, 289, 313.

Government Contracts; Legal Pitfalls and How to Avoid Them. A very complete discussion of the requirements of government contracts by George A. King & William B. King. Eng. Rec. Vol. 52, pp. 676, 713, 748, Vol. 53, pp. 22, 48, 66, 100.

Public Construction Contracts. Report to American Society of Engineering Contractors, by William B. King. Jour. Am. Soc. Eng. Contractors, March 1913, Canadian Eng. Vol. 25, p. 237.

Legal Suggestions Respecting Road Contracts. General principles and discussion of municipal road contracts, by W. L. Bowman. Can. Engr. Vol. 25, p. 860.

A New Form of Government Contract. Describes changes in forms of contracts of the Supervising Architect U. S. Treasury Dept., by Richard D. Micou. Eng. News Vol. 74, p. 109.

Governing Clauses in Engineering Contracts. Discusses some clauses which have caused hardships. Staff article. Eng. Rec. Vol. 65, p. 366.

Some General Principles Applicable to Public Construction Contracts. Statement of Principles which lead to fair contracts. Wm. B. King. Eng. News, Vol. 70, p. 1017.

Some objectionable Provisions in Government Contracts. Discusses advantages of explicitness and fairness by Wm. B. King before American Society Engineering Contractors. Eng. Rec. Vol. 66, p. 589.

Standardizing Public Works Contracts. R. W. Crenzbaur. Eng. News, July 28, 1910. Also Eng. Rec. July 2, 1910.

Standard Contract Forms for Engineering Work. Comparison of standard contract of A. I. A. with current engineering practice. Eng. Rec. Vol. 73, p. 695 and 699.

GUARANTEES

The Abuse of Guarantees. Discussion of fairness and in guarantees. Editorial. Eng. Rec. Vol. 61, p. 771.

Guarantees. On the value of guarantee on a pumping unit. Editorial. Eng. Rec. Vol. 53, p. 665.

Guarantees of Performance. Cites two instances of worthlessness of guarantees. Editorial. Eng. Rec. Vol. 66, p. 142.

INSPECTION

Instructions to Foreman. Manual of rules. J. W. Ferguson Co., Paterson, N. J. Eng. Rec. Vol. 56, p. 573.

General Instructions to Inspectors of Street Paving. Abstract from Bureau of Highway, Borough of Manhattan. Eng. News, Vol. 69, p. 1114.

Instructions for Foreman and Contractors on State Road Construction in Wisconsin. Abstract Bulletin 12—Wis. State Highway Commission. Eng. News, Vol. 70, p. 291.

Contractor, Engineer and Inspector. Value of spirit of fairness and methods of promoting harmony by F. E. Ellis. Eng. Rec. Vol. 68, p. 724.

This Lax Inspection Typical. Discussion of inspection of lumber in Chicago. Eng. Rec. Vol. 72, p. 682.

Enforcement of Specifications. Abstract of Presidential address to Am. Soc. Test. Mat. June 1907, Eng. News, Vol. 58, p. 2.

How Can Better Building Inspection be Secured? Outline of plan to prevent lax inspection. Eng. News, Vol. 36, p. 217.

Co-operation versus Inspection Tyranny on Contract Work. Desirability of experienced inspectors. Editorial. Eng. Rec. Vol. 71, p. 447.

DELAYS AND PENALTIES

A Decision of the Court of Claims on Penalties, by Wm. B. King. Eng. Rec. Vol. 63, p. 453.

Time Penalties on Government Contracts. Court rulings as to duties of owner and contractor. Editorial. Eng. Rec. Vol. 57, p. 587.

Time Penalty Decision by U. S. Supreme Court. Court ruled the penalty valid. Eng. Rec. Vol. 55, p. 633.

Penalty on Liquidated Damages. Defines differences and cites cases. Eng. Rec. Vol. 60, p. 152.

Time Penalties on Contracts. Discusses penalties and liquidated damages, by George A. King. Eng. Rec. Vol. 58, p. 383.

A Court Decision as to the Enforcement of the Time Penalty in Engineering Contracts. Editorial. Eng. News, Vol. 65, p. 602.

Penalty Clauses in Engine Specifications. Discussion of fairness of penalty clauses. The Engineer, Vol. 38, p. 287.

Governmental Responsibility for Delays on Contracts. Court ruling held government liable for unreasonable delay. Editorial. Eng. Rec. Vol. 68, p. 62.

Waiver of Time Limit and Responsibility for Extras. Court ruling in claims concerning the government, by Wm. B. King. Eng. Rec. Vol. 67, p. 48.

Responsibility for Contracting Delays. Discusses causes and effects of delays. Editorial. Eng. Rec. Vol. 66, p. 561.

Delay by Reason of Changes. Cites court decisions regarding responsibility for delays by Geo. A. King. Eng. Rec. Vol. 70, p. 136.

Deduction of Liquidated Damages for Delay. Decisions by U. S. Court of Claims on this question, by Wm. B. King. Eng. Rec. Vol. 66, p. 657.

Penalties and Liquidated Damages. Cites decisions to show uncertainty of law on subject, by Wm. B. King. Eng. Rec. Vol. 69, p. 368.

EXTRA WORK

Payment for Contract Extras. Advantages of Complete Specifications. Editorial. Eng. Rec. Vol. 57, p. 170.

Compensation Claim for Keeping Cofferdam Dry. Cites decision of Comptroller, U. S. Treasury Dept. against Contractor, by Wm. B. King. Eng. Rec. Vol. 67, p. 97.

Comments on Two Specifications Clauses Relating to Extra Work. Criticizes indefinite clauses. Editorial. Eng. News, Vol. 54, p. 42.

A Contractor's Claim for Extra Allowance. States and discusses claim. Editorial. Eng. News, Vol. 71, p. 924.

CHAPTER XV

PREPARATION OF SPECIFICATIONS

§ 156. **Importance.**—The preparation of proper specifications necessary for a clear understanding of the nature of machinery, supplies, or material to be furnished or work to be done under a contract, is as essential for such work as the plans for the same. Each is explanatory of the other, each often incomplete without the other, and unless each is carefully and properly prepared, many disputes and misunderstanding are apt to arise and frequently result in expensive litigation.

From such specifications, bidders not only get their information of the nature and amount of the work they will be called upon to do if this bid is accepted, but they may also form some idea of the fairness of the parties who have prepared the plans and specifications, and of the treatment they are liable to receive during the progress of the work. In many cases these papers are the only introduction of the bidder to the work and to the men with whom he is invited to do business. It is self-evident therefore that in the preparation of such specifications, absolute clearness of details and fairness of intent are essential to secure satisfactory proposals and proper work.

Any specification that is indefinite, indeterminate, ambiguous or useless will involve uncertainties and result in the addition of certain sums by the bidder for self-protection which sums will invariably be far in excess of the actual cost which would result from a definite and exact requirement. Any specifications, therefore, which are arbitrary, unfair or unnecessarily severe, give a bad impression of the engineer, attorney and principals and usually involve either a refusal to bid on the work or additions to the price bid to offset the unwarranted treatment to be expected under such specifications.

A specification is not the place to show the extent of the engineer's knowledge, but it is the place to show how clearly and exactly he can describe the essential and practicable limits of the qualities of work and material needed for the end in view, how well he can protect his client by definite and proper requirements, and how fair and just he will be in his treatment of contractors.

§ 157. **Use of English.**—In the writing of specifications, all that has been said about the use of English applies with especial force. The

language used should be clear, accurate, and exact. The technical terms or vernacular common to the trade to which the specifications apply, may be used, but they must be understood and used correctly. When used they must be defined or be used in the sense which they have acquired through common or local usage, the basis on which they will be legally interpreted.

In the writing of contracts and specifications everything should, if necessary, be sacrificed to clearness. In reports and papers, for the sake of euphony, it is frequently desirable to substitute other words more or less synonymous in order to avoid repetition. In contracts this should be avoided; words are almost never exactly synonymous, and in contracts and specifications the word having the exact meaning should be used as frequently as necessary. In such papers, it is also desirable to express the idea to be conveyed in the clearest possible way, and repetition of the same idea in different words, if it adds to clearness, is not regarded as tautology. Care must be taken however to see that repetition does not obscure rather than clear up the idea to be conveyed. The language must not have a double meaning, and where a subject is described in general and also in particular, care must be exercised to see that the ideas duplicated are identical.

In the Bronx Valley sewer contract, involving \$2,000,000, the engineer described concrete to be used as a 1:2:4 mixture. He then specified that a "batch" of concrete should consist of one barrel of cement (3.85 cu. ft.), two barrels of loose sand (6.50 cu. ft.), and four barrels of stone (13 cu. ft.). The contractor under the last description was required to mix the concrete in the ratio of 1:1.69:3.38, on the basis of the volume used, or even richer on the basis of the volume of loose cement. An action was brought for \$36,000 on account of the excess cement required.¹

In ordinary conversation and in most writings, the words used have a sufficiently clear meaning to convey our ideas for general purposes, for often no great degree of accuracy is necessary. In the writing of specifications, however, these same words are found to be indefinite, and must be defined and qualified to bring out the limited meaning in which they are or should be used. The young engineer is apt to assume that the words he uses have a single and definite meaning and is greatly surprised to find the language he has used and which conveyed to his mind a very definite idea, is susceptible of numerous other interpretations.

¹ See the *Engineering Contractor*, Vol. 2, p. 83.

In practice, the meaning of every term or expression should be analyzed, and whether or not it may have other than the meaning which it is intended to convey, determined. Not only is this analysis necessary, but it is also desirable to consider whether under the contingencies of construction, where perhaps unforeseen conditions arise, the terms may not have still other meanings, or perhaps prove quite inexact and indefinite.

For example: The word "day" may mean the calendar day of 24 hours; the working day, omitting Sundays and holidays; the working day of ten hours; or the shift of twelve or eight hours. The term "ton" may mean the long ton of 2,240 pounds or the short ton of 2,000 pounds. The term "cord," commonly meaning 128 cubic feet, may, by local usage, mean 100 cubic feet. The term "perch" as applied to the measurement of stone work varies radically by local usage from place to place.

§ 158. **Clearness.**—Clearness in all details, both in plans and specifications, is a protection both to the owner and to the contractor, as in one case the contractor is unable to do improper work or avoid the execution of essential features, and on the other hand he is enabled to understand exactly what is desired by the engineer, and can regulate his bid in accordance therewith, without the addition of a percentage to cover uncertain work which he may be obliged to do but which is not clearly specified. Nothing is gained to the party letting the work by uncertainty in the understanding of what is desired, for if such uncertainty exists a careful contractor will add a percentage to cover such contingencies, while an unscrupulous contractor will take advantage of such uncertainties to secure the contract and depend for his profit on his ability to avoid the execution of such portions of the work.

Specifications not only describe the character of the work that the contractor must perform and that the owner must accept, but they also serve as the instructions to superintendents and inspectors as to what requirements they are bound to enforce. It is therefore desirable that the specifications should be susceptible of a literal interpretation not only for a clear understanding between the two parties to the contract but also that the inspectors or superintendents in charge of the work shall know what requirements to impose.

Where much is left to the engineer's judgment, or where unnecessary or practically impossible specifications are imposed (which is always undesirable and inexcusable) friction may perhaps be avoided

if the engineer is experienced and is continually at hand to give his interpretation of obscure clauses, or his permission to disregard inexpedient requirements. An inspector has no such prerogative, unless the same has been especially delegated by his superior and must usually insist (unless fully instructed by the engineer, which should always be, but seldom is, the case) on the fulfillment of the letter of the contract. When the inspector does insist on carrying out an irrational specification, and an appeal is taken to the engineer, if experienced, he must decide in favor of a reasonable interpretation of the specifications which he has prepared. In so doing, the engineer must reverse the decision of the inspector, to his great embarrassment, and to the injury of his confidence in his instructions (the specification), and of his future usefulness. Clearness and exact language in sufficient detail to meet all reasonable contingencies and suitable for literal interpretation, will not only prevent disputes but will add to the efficiency and effectiveness of supervision and inspection.

In order that a specification shall be clear and definite, its paragraphs and clauses should be arranged, so far as practicable, in logical order. Each element should be discussed completely and in detail in a single paragraph or sentence devoted solely to that single feature, and when fully covered should not again be mentioned unless necessary for defining its relation to other features. More than one element should seldom be described in a single paragraph, as such reference tends toward obscurity.

An extreme case of obscurity is illustrated by the following example:²

"All timber standing where levee is to be constructed may be held by the contractor as his own, and he will be allowed an excess of 25% price per cubic yard for filling said muck ditch as in the levee embankment; also the contractor will be required to add 10% to the height of levee above grade line to allow for settling of same."

Here are apparently three distinct subjects treated in a single sentence, and so treated as to leave the reader somewhat in doubt as to the idea intended to be conveyed by their author. Each of these subjects not only would have been more clearly covered by a distinct sentence, but should have had a paragraph devoted to its specific purpose.

§ 159. **Brevity.**—While it is important that every element of the contract shall be clearly, completely and exactly described, it is also

² See Eng. News Sup. Dec. 31, 1903, p. 381.

important and essential for clearness that such description shall be as brief as consistent with a complete and exact description.

A specification is not a treatise on the subject under consideration, and should not be used to impress the client or contractor with the profundity of the engineer's knowledge of the subject. Only those characteristics or features should be specified which are essential in order to secure the results desired. Any paragraph, sentence, or word which can be omitted without material effect on the complete understanding of the subject should be omitted.

The introduction of clauses in the specification which specify nothing except perhaps the uncertainty of the engineer's knowledge of the material or labor to be done are exceedingly undesirable and should be carefully avoided. For example, in many specifications for the foundations for brick pavements which were formerly in vogue in the Upper Mississippi Valley in which the foundation consisted of broken stone, filled with sand and properly rolled, this specification was commonly inserted:

"The sand shall be rolled, with constant light watering to avoid licking up."

What was meant by the latter portion of this clause has always remained a mystery. Possibly its originator had an idea which he thus defectively expressed; others, evidently not knowing what it meant, adopted the clause for fear they would otherwise prepare a defective specification.

Again, a clause relating to the concrete mixer provided "Mixer must be of a size proportionate to the size of the batch mixed," and in the same specification in relation to forms:

"The contractor may adopt any suitable system of moulds for the concrete in place, provided the same be approved by the engineer. The moulds may be fixed or movable, but must be rigid when in place so as to form a concrete accurately."³

Neither of these clauses has any apparent meaning, or at least no meaning which would not be covered by a specification for "a good and workmanlike job."

§ 160. **Indefinite Specifications.**—Carelessness and ignorance of the detailed requirements, which should be included, often lead to indefinite specifications. Such specifications are also sometimes inserted with dishonest or vicious intent. There is often a temptation to write such specifications rather than to take the trouble to consider and to

³ Eng. News Sup., Vol. 51, p. 257.

determine the necessary requirements, at the time the specifications are being prepared. As it is usually provided that the engineer shall interpret or explain any causes not clearly stated, there remains an opportunity for the engineer to decide the matter later, and this also involves an uncertainty and a chance for a considerable variation in expense. Such uncertainties may be and sometimes are used for the purpose of dishonest favoritism. Such uncertainties are manifestly unsatisfactory and unfair, not only to the contractor but to the client of the engineer as well, for they almost always add unnecessary expense. It is only through ignorance, carelessness or dishonesty that specifications are left so indefinite that the contractor can not know exactly what is expected and required, or those which are unnecessary or undesirable are included.

For dishonest purposes, specifications are sometimes drawn so indefinite that no bidder can determine what is required, unless he has inside information, and so many matters may be left to the decision of the engineer that no contractor, unless he knows he will be unduly favored, dare bind himself to the uncertainties involved. For example, in the specifications for a proposed power house for a state institution,⁴ the following stipulations were embodied:

Under the heading "Violation of Contract," the architect was given authority to notify the contractor in writing and within 24 hours after the serving of the notice, the contractor should cease work; the architect was then to have full authority to immediately purchase anything required and take possession of all the materials on the ground or built into the work, and the contractor or bondsman was to meet all bills. While such provisions are both illegal and absurd, no contractor would sign a contract containing such a clause without realizing that a law suit might be necessary in order to maintain his rights.

In another clause relating to changes, it was specified that in case any work was not in accordance with the specifications, the architect would be empowered to accept such work or material and make such a reduction in the contract price as he may determine, which reduction was to be "final, conclusive and without appeal," another absurd and illegal requirement involving, however, the possibilities of favoritism or a suit at law.

In relation to extra work, the following unique and unfair provision was specified: "The contractor hereby agrees to furnish such

⁴ See Eng. News, Vol. 54, p. 602.

materials and to perform such labor as extra work and agrees to accept in full payment thereof a price which shall be fixed by the architect and the board of trustees previous to its commencement." It is quite evident that such a power might work great hardships and perhaps financial ruin to an unfavored contractor, while a favored contractor would profit unduly.

Numerous other similar arbitrary and uncertain provisions were included, all of which either indicated carelessness, ignorance and unfairness or a desire to shut out competition, and to limit the bidding to some favored parties.

The writing of a definite specification, however, is not as easy as may be assumed. A specification which may seem entirely definite may prove indefinite through the various conditions under which it may be exercised. For example:

Engineering News, commenting on indefinite specifications, calls attention to the following: "Specifications (for concrete) for the most part read somewhat as follows:

'Concrete shall be made of one part by volume of Portland cement, $2\frac{1}{2}$ parts by volume of sand, and 5 parts by volume of broken stone.'

"A specification worded like this often becomes a fruitful source of controversy, for there is a great difference in the volume of cement depending upon whether it is packed in the barrel, shaken down in a measuring box, or merely cast loosely into such a box. It is a question for the engineer to decide whether loose or packed measurement will be required, but having decided he should be explicit in writing the specification. The following is a good example of clearness:

'In preparing mortar and concrete, the cement, sand and stone will be mixed in the proportion by volume hereinafter specified. The cement shall be measured when compacted so that 380 lbs. of dry Portland cement have a volume of 3.6 cu. ft. The sand and stone shall be measured when not packed more closely than by throwing it in the usual way into a barrel or box.'" (See Eng. News Sup., Vol. 50, p. 269.)

§ 161. **Indeterminate Specifications.**—When the amount of material or work to be done under a contract is expected to be small, it is customary with some engineers to cover the same with only a brief clause in which the work done and material furnished are to be "as the engineer shall direct." This practice is less objectionable when only a limited quantity of such work or material is to be furnished, but as in most cases there is an uncertainty as to the amount, the practice seems entirely inexcusable.

It may be regarded as proper to give no great amount of space to the specifications for a certain class of material or work where only a small quantity is to be used, but while brief, the requirement should be clear and exact. If the work is worth doing, the contractor has a right to know the exact requirements before he bids for the same, and should not be held subject to the uncertain requirements of an engineer, possibly unknown and inexperienced. The following are examples of such objectionable practice:

"First class compound arch masonry will be laid in mortar. The thickness of the arch, the length and thickness of the stone forming the arch, will be such as the engineer shall prescribe."

Also,

"Concrete is to be made of such material and in such proportions as to material and in such manner as the engineer shall direct."⁵

Even when an attempt is made to briefly draw such specifications, it sometimes occurs that the engineer may, in his haste, specify the material of a greatly superior quality to that which is actually needed in the work. This may prove serious if through an unexpected increase the quantity required is actually large. For example, in a specification for sewers in which only a limited quantity of timber would probably be needed for the foundation work, it was specified:

"Such lumber as is required shall be of a suitable character for the purpose intended, of straight grain and free from all defects."

The first part of this specification might have an entirely different meaning from the last portion of the same, for in few cases would timber "of straight grain and free from all defects" be needed. A cautious contractor, under such a specification, would bid a price which would assure him a reasonable profit under any conditions, while a careless contractor, relying on the first clause of the specification, might sustain a serious loss if a large amount of such material were used.

§ 162. **Ambiguous Specifications.**—Unnecessary or unreasonable requirements are always ambiguous and are uncertain as to what is actually desired, and what will actually be required by the engineer. Under such conditions, responsible contractors will add materially to the price for the work done under such specifications. Not only does this unnecessarily increase the cost of the work, but such specifications also brand their maker as ignorant of the practical requirements of the

⁵ Eng. News Sup., Vol. 51, p. 258.

work, and are a notice to unscrupulous parties that the writer of the specifications is one who may perhaps be manipulated or bluffed into reasonable requirements, or even to extremes in the other direction. It is only too easy to prepare in the office specifications which are impossible to carry out in the field, or which, if carried out, will prove undesirable or expensive.

Specifications that cannot be reasonably enforced except under particular and peculiar circumstances, should be eliminated for where they are included they practically must be ignored except where an absolute necessity for their enforcement arises. This calls for an arbitrary decision by the engineer which a subordinate can seldom be permitted to exercise, and in the exercise of which by the chief he is left open to criticism. For example, in the specifications for concrete, the following clause has frequently been inserted:

"Concrete shall not be dropped into place through a greater distance than one foot." ⁶

A specification of this sort is usually wholly impracticable and should be required only where some injury, possibly by separation of material or injury to new work, might make such an unusual precaution absolutely necessary.

Such a specification, therefore, should not be applied to the entire work, but only to the conditions in which such requirements are necessary, and it would seem desirable to introduce a longer specification in which the methods of depositing the concrete under various conditions should be restricted as far as necessity seems to demand. These extremes should be avoided by the engineer. He should specify only such requirements as are necessary for the completion of the work in the manner desired.

§ 163. **Arbitrary Specifications.**—While it is necessary for the engineer to be able to exercise such control over the work that he can secure its proper performance and completion, it is unwise and unsafe for him to endeavor to exercise unnecessary and arbitrary control over any part of the work. If the contractor is to be held responsible for the work, or for the results obtained, or as to time of completion, safety to the public, etc., he must not be relieved of responsibility through arbitrary specifications, by means of which, the prerogatives of management may be usurped by the engineer.

An extreme case of such usurpation is shown by the following

⁶ Eng. News Sup., Vol. 51, p. 257.

extract from a sewer specification :

"The contractor must employ a competent mechanic, selected by the engineer, who understands and speaks English, and not a common laborer, to make the joints of the pipe sewer." ⁷

A common but extremely arbitrary requirement which may be exercised to a contractor's serious disadvantage, and is therefore undesirable, is as follows :

"The contractor shall commence and prosecute work at such points, at such times and with such forces as the engineer may direct." ⁸

Such a specification is seldom necessary or desirable. The insertion of a time limit clause and of such requirements as to when and where the work is to be begun and prosecuted as may be necessary, will relieve all doubt, and render impossible arbitrary persecution during construction.

Too great and arbitrary authority by the engineer may result in his assuming for his client responsibilities which should be placed on the contractor. For example :

"Before blasting, the contractor must procure a written order from the engineer. Blasts shall be covered with timbers heavily chained together. Caps or other exploders shall in no case be kept in the same place in which dynamite or other explosives are stored; and, in general, the precaution against accidents from blasting shall be entirely satisfactory to the engineer. The contractor shall be liable for all damages to persons or property caused by blasts or explosives." ⁹

If under this clause, the engineer is called upon to specify the precautions to be taken and should an accident occur in spite of the precautions taken, the contractor may reasonably claim that he had acted as servant of the engineer's client and not as an independent contractor, and is therefore blameless.

§ 164. **Unfair Specifications.**—Occasionally in specifications it would seem the purpose of their writer is not only to protect his client in every legal way but also to hamper the contractor by unfair and uncalled for restrictions. Such restrictions can result only in unnecessary expense as they must of necessity limit competition, make the contracting parties doubtful of the good faith of the party preparing the specifications, and suspicious of the treatment which he will actually receive should he be awarded the contract for the work. Such clauses should be eliminated entirely as they have no place in the con-

⁷ Eng. News Sup., Vol. 51, p. 149.

⁸ Eng. News, Vol. 51, p. 149.

⁹ Eng. News, Vol. 51, p. 65.

tract. It is, and should be, the purpose of every attorney or engineer who may be preparing a contract to see that his client is entirely and fully protected, but anything beyond this can give only unsatisfactory results.

It is usually desirable when letting a contract which is finally placed in the hands of a responsible party to prohibit the assigning of the contract to other parties who may not be fully satisfactory. The restrictions, however, should not be so made as to prevent the contractor from being able to properly finance his work by allowing its use as security for money borrowed for its execution. The following clause is an extreme case of this kind. The clauses written are entirely unfair, uncalled for, and may be used as a club for the purpose of persecution or may lead to graft in order to avoid its enforcement:

"It is mutually understood and agreed that if the contractor shall assign or transfer either absolute or conditionally by order or otherwise, the compensation or any part thereof to which he may become entitled under the contract before such compensation is actually earned, the city may, for that reason, cancel the contract and retain all compensation at the time of such assignment or transfer due or owing to the contract; or the city may, at its option, recognize any such assignment and transfer as valid. The option of the city in that regard shall be exercised by the commission of public works, and the recognition of any assignment or transfer as valid shall not preclude the city from cancelling the contract on account of any other or subsequent assignment or transfer. The contractor agrees not to so assign or transfer his compensation, or any part thereof.

"And it is also mutually understood and agreed that the city may, at its option, declare the contractor in default and cancel this contract, in case proceedings in bankruptcy are instituted by or against the contractor (or either of them, if there is more than one), or in case proceedings supplementary to execution are instituted against the contractor (or either of them, if there is more than one); and if the city shall so cancel the contract, it may complete the work or improvement as herein elsewhere provided. Such option shall be exercised by the commissioner of public works." ¹⁰

It is always desirable, when possible, to determine in advance the character of all work required, and to describe it so clearly that an intelligent bid for the same may be made by the contractor.

In underground and subaqueous work it is sometimes impossible to determine in advance just what character of work will be necessary to secure the desired results. When such is the condition, any work which may be required to bring about the desired results should be regarded as extra work, and paid for as such. Any attempt to force

¹⁰ Eng. News Sup., Vol. 52, p. 152.

the contractor to perform such work at his own cost and expense is not only unfair, but will usually result in high bids and unnecessary expense. An example of an unfair specification of this class is as follows:

"Whenever the bottom of the trench is not firm, the contractor must furnish and put in place, without expense, good or suitable material; and when it is considered necessary by the engineer, the contractor shall lay a foundation of timber, without extra expense."¹¹

The intelligent contractor will, of course, add a sufficient amount to fully cover the probable cost of any work which might be required under such a specification as the above, and the engineer's client will pay more than the fair cost of such work. To ask a contractor to assume all risk of conditions and then to assume the risk of what an obviously unfair engineer may think necessary to provide for such unforeseen conditions is, to say the least, unwarranted.

In specifications for work which is covered from sight, not easily reinspected, and not open at all times to ready examination, it is desirable to provide that the engineer may if he desires uncover and open up for his personal examination any work supposed to be complete. In such case it is usually provided that if the work is found to have been constructed in accordance with the plans and specifications, the cost of such examination and of any necessary repairs, shall be at the expense of the engineer's client; but if the work is found faulty in any particular, it shall be replaced and repaired at the expense of the contractor.

Such a clause, permitting re-examination at any time, discourages any attempt at introducing poor work or material either in the absence of the inspector or by collusion, and is fair and just for it involves no expense to the honest contractor, while it means the possibility of an expense to the dishonest contractor greater than any possible saving through defective work. An unfair clause of this general character which would undoubtedly cause an unnecessary increase in the cost of work on account of the uncertainties involved, is as follows:

"The engineer must be permitted to remove such portions of the work as he may from time to time think necessary, for the discovery of improper material or workmanship, and the contractor shall restore such work at his own expense."¹²

It is evident that with such a clause an engineer may greatly annoy a contractor and add materially to the expense of construction.

¹¹ Eng. News Sup., Vol. 50, p. 305.

¹² Eng. News Sup., Vol. 50, p. 365.

Such a clause is not only unfair, but savors of dishonesty as by waiving such examination for a favored contractor, the cost of construction might be greatly reduced.

§ 165. **Unnecessary Severity.**—In drawing specifications for a material only the average requirements which characterize a good material of the class desired should usually be embodied. It is undesirable to make the limiting requirements too severe, unusual or extravagant, as such requirements may materially add to the expense, prevent intelligent bids by driving responsible contractors from the field, prevent the execution of the work, or involve a confession of error and have to be modified to the embarrassment of their writer. Too often the minimum limits of a specified test are fixed at or near the maximum that has been secured from tests of the best of similar material. Frequently the results specified are impossible to obtain on the average, especially when a material is new on the market. Such severe requirements are usually in error and are seldom if ever necessary. The requirements for a good average material are more readily enforceable, and any additional safety required should, if possible, be secured by improvement in design.

In the early days of brick paving, when the number of paving brick factories was still small, a test of paving brick from one of the smaller factories showed that the best class of material would not absorb more than $1\frac{1}{2}$ per cent of water. Based on these tests, it was suggested that specifications for this material should place this limit as the requirement for brick for paving. At the particular time in question, the factory mentioned could not have supplied more than one-half million brick per year, and few if any other factories were, at that time, turning out brick which would comply with such a specification. Nevertheless such a specification was adopted for a paving contract involving about six million brick, and had to be waived before the construction of the pavements in question was possible.

§ 166. **Specifications for Criticism.**—The student should consider one or more of the following specifications, and both criticise the specification as written and rewrite the specification so as to assure proper results or to express the meaning (which should have been expressed) in clear and unequivocal language. The student should examine critically each specification to see wherein it is obscure, verbose, indefinite, indeterminate, ambiguous, arbitrary or unfair.

1. "Broken stone shall be of quality approved by the engineer and shall be of cubes of such size as will pass through a two inch ring."—Eng. News Sup., Vol. 51, p. 149.

2. "The contractor must employ a competent mechanic, selected by the engineer, who understands and speaks English, and not a common laborer, to make the joints of the pipe sewer."—Eng. News Sup., Vol. 51, p. 149.

3. "Should the engineer so desire, 50% of the stone (for the concrete) may be replaced by gravel, perfectly free from sand."—Eng. News Sup., Vol. 51, p. 129.

4. "The mortar used in masonry and brick work shall be made of hydraulic cement and sand, or lime and sand, or a combination of hydraulic cement, lime and sand, according as the engineer may direct. It shall be mixed in such proportion and made and used in such manner and within such time after mixing as he shall prescribe and direct."—Eng. News Sup., Vol. 51, p. 49.

5. "The engineer must be permitted to remove such portions of the work as he may from time to time think necessary for discovery of improper materials or workmanship, and the contractor shall restore such work at his own expense."—Eng. News Sup., Vol. 50, p. 365.

6. "All timber used in the trench and left there shall be paid for at current rates."—Eng. News Sup., Vol. 50, p. 305.

7. "In accordance with our conversation this morning, I hereby agree to rent you 12 wheel scrapers at 50 cents each per day."—Eng. News Sup., Vol. 51, p. 169.

8. "The State Engineer shall between the first and fifteenth days of each month make and file with the Superintendent of Public Works, an estimate of the amount, character and quantity of work done and of material which has actually been put in place in accordance with the terms and conditions of this contract during the preceding month, and compute the value thereof. The Superintendent of Public Works may within fifteen days thereafter at his office, pay to the contractor from the money which shall have been appropriated for that purpose, a sum not to exceed ninety per cent of the value of the work performed and material furnished as so certified by the Engineer."—Eng. Rec. July 27, 1907, p. 85.

9. "Trenches shall be filled with special care. The engineer may, if he deems necessary, require one man tamping to each man filling in, or may require the contractor to puddle the filling with water without extra compensation."—Eng. News Sup., Vol. 50, p. 125.

10. "It is expressly specified that in entering into the agreement to perform the work herein specified, the contractor admits that he has read each and every clause of these specifications and the circular of instructions, fully understands the meaning of the same, and that he will comply with all the requirements herein set forth."—Eng. News Sup., Vol. 50, p. 321.

11. "The sewer will be measured along its center line. The price bid per lineal foot of sewer will include all expense for labor and for material needed to complete the sewer; and no additional payment will be made for bracing, pumping, street repairing or any other thing involved in completing the sewer."—Eng. News Sup., Vol. 50, p. 257.

12. "All clay and spongy material shall be removed to a depth to be determined by the engineer (not exceeding 12 inches below the bottom of the macadam), and shall be replaced with such material as the engineer may direct."—Eng. News Sup., Vol. 50, p. 257.

13. "*Superstructure for Paving.*—Consisting of four inches deep after rolling and ramming solid sand and gravel or hard coal cinders; under course of bricks laid flat; one inch sand bedding after rolling solid; top finished course—vitrified bricks paved on edge, racked with sand as follows:

"The superstructure for paving shall be executed to such depth below the underside of the top brick course as will admit a layer of solid sand and the top finished paving. If such said depth below the underside of the top brick course be not too shallow, shall receive a foundation of sand and gravel so directed, under course bricks laid flat, with one inch of sand bedding for finished paving."

14. "At a depth of seven inches below underside of top brick course, the formation shall receive a layer of sand and gravel to pass a two and one-half inch ring, or hard coal cinders as shall be directed, four inches in thickness after ramming and rolling solid with a five ton roller, to receive layer of flat brick paving, one inch sand bedding and top course."

15 "The paving bricks shall consist of the very best quality of vitrified bricks used for paving purposes. They shall be thoroughly sound vitrified through, and shall withstand all tests brought to bear as to their fitness, and shall not contain lime, etc., to such extent as to cause them to fracture after being immersed in water eight (8) days, and shall show a modulus of rupture not less than eighteen hundred (1,800) pounds to the square inch, and absorption not less than one and five-tenths (1.5) per cent. This average shall not be varied from more than twenty (20) per cent."

16. "The transverse courses of top finished paving shall be laid on edge, perfectly at right angles with the line of curbs and in perfectly straight lines, laid and tested to a cord-line and plumb-bob."

17. "As the work proceeds, any portion not actually covered by the finished paving; or any ground that may have been opened to the formation level, shall be kept from exposure to storms and inclemency of the weather by oil sheet tarpaulins provided for the purpose. If at any time the formation is allowed to get wet, soft or cut up, it shall be taken out to such depth as directed by the engineer, and replaced with sand and gravel or hard coal cinders, thoroughly tamped and rolled, as directed by the engineer, without extra charge or cost."

18. "The committee shall have power at any time to alter, amend and do anything relating to the quantity or quality and description of materials or workmanship, or to add to, or reduce any of the work without in any way annulling the contract, and the contractor shall comply with these terms in every respect, the same as if no alteration in any respect had been made, without extra cost or claims, or in any case, should there not be a price returned or provided for in the schedule contained in the contractor's bid for anything required or called for whether the same is specified or not, for materials supplied, built and fixed in place, or workmanship, then such price shall be allowed by the engineer as in his opinion is reasonable and fair, and according to its market value. If such alterations diminish the work to be done, they shall not constitute a claim for damages or for anticipated profits on the work dispensed with."

LITERATURE

The Writing of Specifications. Points to be observed in preparation of specification, by H. P. Breitenbach. Eng. News, March 7, 1912, p. 443.

Specifications. Address to students of Rensselaer Polytechnic Inst., by Theo. Cooper. Eng. Rec. Apr. 15, 1893, p. 395.

Notes on Preparing Specifications, U. S. Reclamation Service. Some principles to be observed. Eng. News, Vol. 57, p. 649. Eng. Rec. Vol. 55, p. 701.

The Making of Specifications. Abstract from address to Am. Soc. Test Mat. 1903, by Dr. C. B. Dudley. Eng. News, Vol. 50, p. 39.

Alternate Specifications for Public Work. Discussion showing that all bids should be made on same basis, by C. D. Hill. Eng. News, Vol. 74, No. 25.

The Application of Specifications. Presidential Address before 16th annual meeting Am. Assoc. Test. Mat. by Robert W. Hunt. Eng. News, Vol. 70, p. 20.

Engineers, Contractors and Specifications. Criticism of unfair and indefinite specifications. Editorial. Eng. News, Vol. 48, p. 213.

Relation between Research and Technical Society Activities. Extracts from address to Am. Soc. Test. Mat. June, 1914. A. N. Talbot. Value of research in writing specifications. Eng. Rec. Vol. 70, p. 36.

Who Should Prepare Specifications? Editorial. Discusses advantages of using standard specifications and objections to specifications prepared by interested parties such as manufacturer. Eng. News, Vol. 36, pp. 121, 154.

Clear Specifying and the Nova Scotian Steel-Coal Lawsuit. Desirability of explicit specifications. Editorial. Eng. News, Vol. 61, p. 386.

The Evils of Indefinite Plans and Specifications. Editorial. Eng. Rec. Vol. 70, p. 655.

Square Deal Specifications. Desirability of explicit and fair specifications. Eng. Rec. Vol. 55, p. 454.

Engineers' Contracts and Specifications from the Contractors' Point of view. Abstract of paper before Boston Soc. C. E. by J. W. Rollins, Jr., Eng. News, Vol. 58, p. 356.

A Court decision that Specifications on Public Work must accurately define the work. Editorial. Eng. News, Vol. 55, p. 128.

Contract Obligations in the Steel Trade. Abstract of paper before Am. Iron & Steel Inst. gives fundamental conditions in contracts, by E. A. S. Clarke. Can. Eng. Vol. 23, p. 229.

CHAPTER XVI

TECHNICAL SPECIFICATIONS

§ 167. **Breadth of Knowledge Necessary.**—Engineering specifications may cover almost any phase of industrial activity, and it is obvious that no individual can, from his experience and immediate knowledge, be prepared to write suitable specifications for all of the multitude of engineering and architectural works, machines, materials and processes for which such specifications are sometimes needed. Even where the specifications are for matters within the experience and knowledge of the individual, and even though he has frequently prepared similar papers, the difference in conditions, the advances in the art, the improvements in methods, and the special economies possible, usually require thoughtful preparation and a readjustment of the ideas that have previously been embodied in such papers.

In almost every important work, new conditions and new requirements may involve detailed methods not fully familiar or possibly even quite unfamiliar to the engineer in charge, and he is obliged to prepare a specification for an object or result somewhat beyond his experience.

In all cases, and particularly in the case last mentioned, the engineer must know either by experience or by investigation, the nature of the material and processes best adapted to the particular case at hand, and the limitations and restrictions that it is desirable and commercially possible or practicable to specify for the guidance in furnishing the material and doing the work of construction. Every source of information should be utilized, and even these will often be found too limited for his full information.

§ 168. **Detailed Information Needed.**—In the preparation of technical specifications, it is essential that the engineer should possess a comprehensive and detailed knowledge of:

First. The qualities and characteristics of the various materials to be used and the practicable limits to which the qualities necessary for the work in question should be restricted.

Second. The usual and practicable methods of performing the work to be done in such a manner that it will be completed without unnecessary expense and in a manner satisfactory for the purpose which it is to fulfill.

Both requirements presuppose a somewhat broad and complete knowledge of the material and processes considered. Such a knowledge is acquired only by extended study, observation and experience, and is not usually possessed by the young engineer or by an engineer who has been called upon to undertake work in lines somewhat different from his previous practice. In such cases, systematic study, including observation and investigation, can only partially take the place of the knowledge gained by experience, and without systematic study such specifications cannot be properly prepared. In many cases, experience is absolutely necessary, for the necessary requirements which should be included in correct specifications are not always sufficiently elaborated in available technical papers or books, nor is it always practicable to obtain a sufficient knowledge of the same through limited observation and investigation.

Third. The ability to designate in detail the composition or elements of the material or processes and the methods to be used for their proper production and utilization or the ability to design in detail the structure, machine or plant contemplated.

Fourth. A knowledge of the methods ordinarily employed by the mechanics or operatives in the manufacture of the product or machine and in the construction and operation or maintenance of the plant or structure.

Fifth. The experience which will foresee the necessary materials and methods to be employed, difficulties to be overcome, and contingencies to be met in the work.

The more complete the knowledge of the subject, the better the specification, provided the engineer has the ability to express his knowledge in clear and exact language.

No engineer can evolve from his inner consciousness adequate specifications for engineering work; and even after extended experience, the intelligent engineer will frequently find ways in which his specifications can be materially improved. Extended study, observation and investigation must therefore precede the preparation of any specification, and especially in lines which are new to their writer.

§ 169. **Outline.**—The detailed requirements of the specifications for even a single fundamental material or process are seldom so simple that they can be clearly kept in mind for the purpose of specification writing without danger of serious omissions. In the preparation of specifications for engineering and architectural works, the materials are so many, the processes so numerous, and the various parts and

divisions are so manifold that some material, process or part is apt to be overlooked and omitted unless special precautions are observed.

Reliance on the memory to retain all these matters is inexpedient, as most engineers have experienced to their great embarrassment. From similar experiences, the author was led to adopt the analytical method here outlined, which he has used with satisfaction in his practice for almost thirty years.

The general plan to be pursued in the preparation of these outlines is to carefully divide the work to be done into its various elements, and to set down in detail all materials and processes which must be included, still further subdividing and analyzing the essential features or requirements of each. In the cases of fundamental material or processes, the qualities or operations that should be limited or controlled should be similarly differentiated, classified and outlined.

The engineer should keep his note book constantly at hand when considering an improvement, whether in the office, the field, or the drafting room, and carefully note such points as he desires to introduce in the completed work, and embody such points in his outline and specifications.

The purpose of the analysis suggested is to arrange in a logical order the detailed subject matter for any given specification, covering in each case completely, or as nearly as practicable, the entire subject to be considered. In general such an outline should include all items that should ordinarily be embraced in a specification for similar material, process or work. The outlines should be sufficiently complete to cover all ordinary conditions and requirements and in their use they should be carefully scrutinized to see that they include every item necessary for each particular case.

With this analytical method of specification writing, collections of specifications of able engineers on various important works are of great value as suggestions, and will greatly facilitate the preparation of such outlines.

A careful analysis of the work to be done or material to be furnished under any contract, is essential to rapid, accurate and successful specification writing.

In the actual writing of specifications, all of the items in a complete outline will seldom be used for the particular work in hand, and often a brief memoranda may embrace all that it is essential or desirable to mention.

In practice, for each particular piece of work for which specifications are to be prepared, a special outline in logical order may be

first drawn up in which should be included all items necessary for the particular work. From a correct outline of this kind the specifications can be drawn with little chance of omission of important matters.

After a correct outline is drawn, the specifications under each heading may be written, or clauses from such other specifications as the engineer desires to use as models, may be used so far as they apply to the work in hand. It is essential, however, that their bearing should be carefully scrutinized, and no specifications should be introduced which do not distinctly apply to the work in question.¹

§ 170. **The Use of Published Specifications.**—In the preparation of technical specifications on lines that differ somewhat from those embraced in the experience of their engineer, the usual method has been to select as a basis for the new specifications, similar specifications which have been used on other more or less similar work, and which are judged by the engineer to be satisfactory.

An intelligent study and analysis of specifications which have already been prepared for similar work, especially where the experience of their author renders them authoritative, is of great value and importance.

There is no better source of information than well prepared specifications nor a better method of study than by a comparison of the practice of a number of experienced engineers as expressed by their specifications, and no better method of preparation than the adoption of well considered phrases and entire clauses that are really applicable to the case at hand. The error which commonly follows this practice lies in the abuse of such a method, and such errors can be overcome and this means of acquiring information utilized to advantage only by a full and careful analysis and comprehensive study of the subject. There is no way of accomplishing the object sought without hard and unremitting study, and investigation and professional success are dependent on an appreciation of these requirements no less than on other professional knowledge and experience.

The rewriting of a well prepared clause which clearly and definitely specifies the qualities or limitations desired in order to simply effect originality is not advocated. Originality in specification writ-

¹ Similar outlines to those suggested are published:

1st. In Sweet's Catalogue of Building Construction. (See checking list for specifications and estimates.)

2d. In The Engineering Catalogues and Specification Digest, issued by the Engineering Magazine. (See Specification Digest.)

ing is not a desirable object. In most cases the more original a specification is, the poorer it is. Well established precedent is a safe guide to follow, especially when proceeding beyond the domain of personal experience, but it is essential to *determine that a precedent is well established* and is a proper precedent for the condition at hand.

In selecting for use specifications prepared by others, they should be modified as the conditions demand. This method has given and will give good results by careful discrimination and intelligent study, but it too often degenerates into simply copying with slight changes, the clauses prepared in previously executed work, the importance of which frequently differs from the work on hand and the conditions of which often vary largely from the work for which the new specifications are to be used. To prepare a good specification will therefore require much more than even the judicious copying of other specifications.

A well and properly written specification will seldom apply in detail to other than the work for which it is prepared, and the use of such specifications on entirely different work under radically different conditions and without careful initial study and consideration of their application in detail, can lead only to unsatisfactory results and is inexcusable. The unintelligent copying of such specifications should be studiously avoided. Such a method of preparation, which is altogether too common, is apt to bring embarrassment and shame on those who follow it.

If the engineer is in too much of a hurry or is too indolent to study his subject and to properly inform himself, he is quite sure to copy those clauses which he does not understand, as such clauses will appeal to him as possibly highly essential for the perfection of his specifications, while frequently they will have no bearing whatever on his particular case, and the introduction of a clause not pertinent to the object at hand is a notice to contractors and manufacturers that their author is ignorant of his subject.

In the careless use of this method of preparing specifications, certain specifications are often selected only because they have been used on important work in other places and have to the unsophisticated engineer, a learned sound and not because there is any necessity for their introduction for the particular work in question. In this manner certain specifications are sometimes copied and recopied until they have lost any shade of meaning; and in other cases, specifications are copied which may have no application whatever to the case in hand.

While the insertion of useless specifications is objectionable, inasmuch as they display ignorance of their writer in regard to the work at hand, yet they are ordinarily meaningless and their insertion is not so serious as the omission of important specifications, which is perhaps a still more common occurrence.

Among the dangers of copying a specification is that the specification is often incomplete unless the drawing of the work, which is an integral part of the same, is also considered. Dimensions shown on the drawings are seldom repeated in the specifications; hence if the specifications are carelessly copied, without due consideration, they may be considered as complete in themselves, where such is not the case. Take, for example, the following clause for a pavement:

"Upon this sand cushion shall be laid a pavement of asphalt blocks. The blocks shall be 4" in width and 12" in length."

It will be noted that the depth of the block is not mentioned, such depth being doubtlessly shown on the drawing to which the specifications refer.

§ 171. **Simple Specifications.**—In the performance of the simpler forms of labor, and in the purchase of the simpler materials or supplies, and even of simpler and smaller machines which have become standard, the necessary specifications are often of the simplest kind. Simple specifications may require only a plain and exact statement of the conditions that exist and the general nature of the machine or structure required to satisfy those conditions. Such specifications require no elaborate special knowledge in their preparation, but such knowledge may be required when bids are received in order that an intelligent choice may be made as to the manner and method in which they will be best fulfilled.

The preparation of such specifications do require a complete comprehension of the conditions and the ability to outline them clearly and completely, so that manufacturers or contractors will know how the requirements are to be met.

In order to permit of competition in matters wherein certain methods or details are controlled by or are peculiar to certain individuals or firms, the specification must be left open and should require that the proposal be accompanied by manufacturers' or proprietors' specifications, defining in detail the material, machinery or construction which it is proposed to furnish under a specific bid.

In all cases, where the specifications are only general in character, the contractor may be required to furnish the detailed specifications

and perhaps detailed plans with his bid, describing and showing therein the special details he proposes to furnish. Such specifications are usually requested under some general specifications, as follows:

“The contractor shall furnish specifications describing in detail the character of the work and material to be furnished by him under this contract. Such specifications, when accepted by the party of the first part and attached herein, shall be marked ‘Exhibit ...,’ and shall constitute an essential part hereof, and the work furnished hereunder must strictly conform thereto.”

§ 172. **Detailed Specifications.**—As the construction becomes more elaborate and details increase, it becomes more and more essential that the specifications be complete and in detail, for with the increase in details comes also greater uncertainty in regard to the character of the material and the methods of construction which may be used. The specifications are intended to fix these details beyond question, and to confine the character of the materials, workmanship and design within necessary limits.

The preparation of such specifications requires an extensive technical knowledge of materials, processes, designs and construction, including a knowledge and appreciation of commercial conditions and limitations which may influence the cost and efficiency of the results desired.

In some cases where detailed plans and specifications are supplied, it may also be desirable to ask manufacturers or expert contractors having special experience, to submit bids not only on the engineers’ plans and specifications but also on special plans and specifications, embodying their own ideas and practice.

§ 173. **Modifications of Requirements.**—In the preparation of specifications, especially for public work, it is important that provisions should be made for such modifications in the methods which are to be pursued and the materials that are to be used as are likely to be required, as any modification by the engineer in the strict requirements of the specifications are apt to subject him to severe although possibly unwarranted criticism. For example: in the specifications for concrete or for placing the same (see Sec. 220), it is desirable if there is any chance that modifications in the character of the mixture or process will be desirable, to provide in the specifications for such modifications and for the less or greater compensation to the contractor for the amount of work in which such modifications are made. The same rule should, of course, apply to all other materials and work in which modifications may become necessary.

§ 174. **The Use of Standard Materials and Methods.**—Specifications not only bind the contractor to perform his work in a certain manner, and to furnish material of a certain grade, but they also greatly influence the cost of the work and material so furnished. In ordinary practice it is desirable to specify only such character of machines, material, supplies or methods as may be found on the market and in general use. Unusual characteristics, modifications of standard machines, and the introduction of new methods, should be specified only when such unusual requirements are clearly needed to secure the best results and after an investigation has clearly shown that the additional expense involved is commensurate with the better results to be obtained.

Neither the best nor the cheapest is uniformly desirable or applicable, and the ideal quality for the specific conditions in immediate question should be the aim in each case. Unnecessary requirements and restrictions as to the quality or character of material and supplies or of unusual methods of construction will add unnecessarily to the expense involved and are a serious error. Such specifications are only too common and frequently result in unwarranted expense, serious trouble and sometimes in legal complications.

§ 175. **Influence of Specifications on Material and Methods.**—While it is largely true, especially in small works, that the engineer must use these materials, products and methods which are usual and available and have the endorsement of common usage, it is also true that all such commercial products are slowly but surely modified and shaped by the demands of the best practice. The manufacturer who offers a material or a machine which is not up to standard requirements, must sell to the ignorant or to others at a considerable disadvantage, for a reduction in price for an inferior article may sometimes compensate for lack of a higher degree of perfection. If a machine or material is found more or less unsuited for the purpose for which it is used, and that purpose is of importance, its users will soon demand such changes in its qualities as will make it more satisfactory; and the engineer in charge of the designs, dependent upon its use, or of the plants in which it may be needed as a necessary supply, should investigate its quality, see in what ways it may be improved and prepare specifications which will bring about the required improvements. Such improvements can be brought about only by expert investigation and a full knowledge of the subject; and the specifications must be made along practicable lines.

The Altoona laboratories of the Pennsylvania Railroad are devoted to such work, and the investigation and specifications, and the resulting betterments in materials and supplies furnished to that company are examples of the best practice in specification writing.²

§ 176. **Responsibility.**—The more general the specifications, the greater the degree of responsibility which the contractor should be required to accept. As the details are defined by the specifications, the contractor's responsibility must of necessity decrease, for neither morally nor legally can a man be held responsible for results which are entirely beyond his control.

In fixing responsibility by means of tests and guarantees, the item of the expense involved must be carefully noted, for, especially in smaller contracts, such requirements sometimes involve a considerable extra expense.

It is frequently better to purchase a standard article from a manufacturer of known repute, from whom the engineer is aware he can secure a machine which will give certain well-known results, than to purchase a similar article under unusual guarantee from unknown parties and then forego the test on account of the expense involved.

Responsible manufacturers frequently refuse guarantees on small contracts unless the tests are made at their own factories, or unless the expense of such a test is covered by an additional compensation to meet the cost of making them.

The contractor should always be held responsible for the class of workmanship and material desired, and his responsibility in these matters should be carefully covered in the specifications.

§ 177. **Definite Requirements.**—In the preparation of specifications for materials, processes, machinery or works with which the engineer is more or less unfamiliar, there is always a tendency to cover ignorance by indefinite requirements.

Indefinite specifications should, wherever possible, be carefully excluded from all specifications, and from machinery specifications in particular. If it is essential to specify limiting stresses in machine parts, then the limits should be specified in exact language, and they should not be specified to be "ample" or "sufficient." Such specifications are valueless for they leave the matter wide open for irrespon-

² The Influence of Specifications on Commercial Products, by C. D. Dudley. Address Am. Soc. for Testing Materials, 1904. See Eng. News, Vol. 51, p. 592.

sible manufacturers to do improper work, and trust to the ignorance of the engineer to pass it on inspection, while with reputable makers such clauses are wholly unnecessary.

The question as to what the terms "ample," "sufficient," etc., are intended to cover, must finally be decided if the machine is to be accepted or rejected on such a basis, and it will greatly aid in the clearness of the specifications if such questions are decided in the first place and the exact requirements inserted in place of the indefinite ones. General specifications in regard to workmanship must, from their nature, necessarily be somewhat inexact and indefinite, but when such clauses must be used they should be as carefully defined as possible. When necessary such clauses may be embodied in the specifications and defined by a specification somewhat as follows:

"Whenever on account of the nature of the workmanship or material to be furnished, the specifications defining the same are, from the nature of such work or material, inexact or indefinite, and are specified to be 'first-class,' or 'satisfactory,' or by other terms in which the judgment of the individual may vary, then and in that event, the engineer shall be the sole judge of the fulfillment of the same."

Such a clause should, however, be used with care, as few contractors or manufacturers care to put themselves into the hands of an inexperienced or incompetent party.

§ 178. **Standard Specifications.**—Various technical societies and associations have from time to time adopted "standard specifications" for certain materials, processes and structures. In general, such specifications have received the careful consideration of experts who have had much experience in the manufacture and use of the material and are the result of a very free and full discussion of the various practicable requirements of such manufacture and use. When such specifications are available for a material to be used in construction, their adoption by the engineer seems to be desirable unless the peculiar conditions of the case in hand make changes in the requirements essential. The standard specification and its requirements are usually widely known to manufacturers and contractors, and the cost of the material, as subject to such specification, is readily determined. Requirements more severe or radically different from a well established standard may seriously affect and render uncertain the prices which may be demanded. Departure from such standards should therefore be made with care and only for good and sufficient reasons.

As such specifications are often well known and widely published, it is seldom necessary to embody them in detail in the specifications prepared by the engineer, but they may be made a part of such specification by distinct references.

Such specifications are:

Specifications for Portland cement, adopted by the American Society of Civil Engineers.

Specifications for underwriters' fire hose, adopted by the Associated Factory Mutual Fire Insurance Companies.

Specifications for structural steel, as adopted by the Steel Manufacturers' Association.

Other references to similar specifications will be found in the Bibliography at the end of this volume under the heading of *Standard Specifications*.

With the development of the arts and the experience of time, these specifications are changed, and in referring to them the date of the adoption of the specifications should always be given. Such specifications may be introduced into the contract by a reference as follows:

"The material or work to be furnished under this contract shall be in strict accordance with the specifications for Structural Steel, adopted by the Steel Manufacturers' Association of (date), and which are hereby made a part hereof."

LITERATURE

Copying Specifications. Objections to the practice. Editorial. Eng. Rec. Vol. 65, p. 477.

Influence of Specifications on Commercial Products. Abstract annual presidential address to American Soc. Test. Mat. 1904. Dr. C. B. Dudley. Eng. News, Vol. 51, p. 502.

Needed Improvements in the Art of Testing Materials. The Outlook for uniform International specifications for materials. Abstract from address before Am. Soc. Test. Mat. June 27, 1911. Henry M. Howe. Eng. News, Vol. 66, p. 53, and Eng. Rec. Vol. 64, p. 14.

Specifying by Reference to Standards. Discussion of advantages and disadvantages of such practice. Editorial. Eng. News, Vol. 53, p. 554.

Concerning Bridge Steel and Ship Steel. Discussion giving the advantages of unification of specifications for steel for similar purposes. Editorial. Eng. News, Vol. 57, p. 622.

Railway Construction. Need of uniform specifications. Eng. News, Vol. 49, p. 501.

CHAPTER XVII

SPECIFICATIONS FOR FUNDAMENTAL MATERIAL AND SUPPLIES

§ 179. **Fundamental Elements of Specifications.**—Fundamental materials and processes are first introduced in the discussion of specifications not on account of their simplicity but on account of the fact that engineering or architectural work is made up of a series of such elements, and proper specifications of fundamental materials, supplies and processes, united together in a complete and consistent whole, will constitute a correct description of the technical requirements.

There are in fact no specifications more difficult to prepare than those for fundamental materials and processes. Their accurate preparation necessitates a complete and definite knowledge of elementary details not commonly possessed by any except those who have given the subject extensive study. As the various materials and processes are so numerous, a detailed knowledge of their practicable limitations and the extent to which their qualifications should be modified and controlled in a specification is not the common knowledge of the engineer.

Frequently such knowledge is not generally available and the importance of the material is not sufficient to warrant the expense of a sufficient investigation or of suitable tests and experiments to form the basis of a sound specification in which the composition, method of manufacture or specific test requirements can be intelligently and specifically set forth. This is particularly true of new materials, proprietary articles and various supplies.

§ 180. **Practical Limitations of Specifications.**—The possibility of an intelligent specification depends on the existence of a certain amount of definite knowledge which can be clearly outlined, covering the composition or character of material, the methods of construction or manufacture, or certain test results which are to be obtained and which will actually indicate the character of the material. In the early development of any material, machine, structure or process an attempt is made to accomplish certain results in a certain way. The attempt is a failure and is abandoned, or it meets with greater or less success in accomplishing the object sought. In the latter case, various troubles arise as time passes; early success may be followed by partial

failure with other and more severe conditions, and such failures may or may not be obviated by changes in composition, methods of manufacture or design. The development may be successful under certain conditions and a failure under others. In each case a knowledge of the limits of application and composition become gradually known and appreciated. The designer, manufacturer or producer acquires a certain knowledge of the development and of the effect of variations in its composition or design on its utility under various circumstances, and such knowledge is not usually available to the purchaser or consumer except when the development has been extensively applied, and then only after a wide and comprehensive inquiry. The purchaser frequently acquires a very definite knowledge of the application of a material to his particular requirements, and especially the effects of time and use on its ultimate success.

The producer, if his product is reasonably successful, desiring to introduce it for the broadest application while bettering his products as the demands require, is not likely to give the purchaser any further knowledge of the contingencies involved than his own interests warrant. He is unwise if he permits the product to be used where failure will inevitably result, for such failure will prejudice its future use; but he must run certain chances if failure in order to extend the use of the products to new and untried fields.

The purchaser secures the product which from his investigation seems most likely to give the results he desires; he endeavors by investigation, by preparing specifications and by requiring guarantees and tests, to protect his interests. These he must limit in accordance with the necessities of the case and the expense involved. He must assume certain risks or stand the expense of assured results which would frequently lead to great difficulty and unwarranted expense, especially in a new product. Gradually the use of a product becomes more and more extended, other similar products arise and purchasers increase in number. The application of the product is widely discussed, the difficulties in its use become known, the effects of design, of composition and of method of manufacture become appreciated. Under these conditions the product can be more or less controlled by specifications, for certain definite and fundamental knowledge becomes available to all on suitable inquiry. The product may become standardized in its common application, and by reference to such standards easily limited by purchasers with normal intelligence and having even relatively slight knowledge and experience.

In the inception of the development no standards are possible; a certain risk is necessary if the product is to be used and such risk is common both to the producer and purchaser, and must be divided in such equitable manner as the circumstances require.

The producer desires to place his product on the market and to make it an ultimate success. His experience and his finances may permit of his warranty, and his reputation and responsibility may make such warranty acceptable to the purchaser. The warranty involves expense, replacements are necessary and damages may be involved, but finally experience is acquired, success more or less definite is established, the guarantees can be more and more limited or may become entirely unnecessary, for the product has become standard and its use within certain limits recognized as a practical success.

It is evident that detailed specifications should be limited to those materials and supplies in the manufacture of which the composition, methods of manufacture and results attained can be intelligently controlled for a useful purpose. If the composition and methods of manufacture materially affect the results which will be obtained in the use of the materials, limitations of both composition and methods may be desirable; but if a knowledge of the effect of composition and method is not available, a specification in which an attempt is made to control these factors is useless or worse. It is evident that any specification which will involve unnecessary inconvenience or extra expense to the manufacturer will be undertaken only when the amount of the material required and the price that can be obtained make it worth while, and the extra expense will be warranted only by definite and positive advantages to be gained.

§ 181. **"To the Satisfaction of the Engineer."**--As with every other subject, so in specification writing, it is much easier to deal with generalities in more or less vague and meaningless phrases and to finally limit the so-called specification by the requirement that the material or process shall be furnished or done to the complete satisfaction of the engineer. The engineer may not, and frequently does not know with just what details he will be satisfied. The matter is often uncertain in his own mind and he relies on the chances of his ascertaining by study or through professional inspiration the limitations which will permit him to pass upon the matter with possible credit when the emergency for a necessary decision arises. The contractor, on his part, takes the chance on the probability that the engineer will be satisfied with reasonable requirements.

Where the material or process required is only a small portion of the complete construction, the specifications need not be elaborate, and the requirement that it be "satisfactory" may be a reasonable one. Where, however, the material constitutes a large and important part of a contract, it is highly desirable and essential to good practice that the specifications be reasonably definite and complete, and the chemical or physical qualities or test requirements be so completely specified as to leave no doubt in the minds of either party as to what is required.

§ 182. **Specifications by Name Only.**—The simple name of a material is usually quite insufficient as a basis for a bid or contract unless it be accompanied by a previous inspection by a party conversant with the needs to which it is to be applied.

No material is so pure, unadulterated or uniform in quality that its name carries with it and assures the possession of the necessary qualifications for the purpose for which it is to be used. Every material has more or less impurities besides the basic material signified by its name, and no alloy is sufficiently described, as to constituents, by the commercial name ordinarily applied to it. Iron and steel range widely in characteristics in accordance with the variation in the constitutional elements and the processes used in their production, and certain limitations and requirements must be specified whenever the most common and ordinary forms of these materials are not sufficient for the purposes to which they are to be applied. Brasses, bronzes and other alloys vary widely in their composition and consequent character, and while practice frequently places a certain limit or range to the composition designated by a certain name, it will seldom if ever so closely define that composition as to render unnecessary a detailed specification.

The important work of the Pennsylvania Railway testing laboratory at Altoona is devoted largely to specifications for materials, and the amount of labor involved and time necessary for their adequate preparation are very great. Almost the entire activities of the American Society for Testing Materials are devoted to the questions of specifications for materials.

The uncertainties resulting from inadequate specifications are well illustrated by a case recently tried in an Eastern court. A company placed an order with a steel foundry company as follows:

"Six tray lips, pattern A—1044. These lips are to be of vanadium cast steel 0.35 to 0.45 carbon annealed. Care should be taken that the metal in the cutting edges is solid and of the best quality."

These castings when received and upon use were very unsatisfactory. Some broke within a few hours and all broke within a comparatively short time under less service than some of the ordinary open hearth tray lips previously used. Payment for the lips was refused, and suit entered during the testimony developed as follows:³

"The superintendent of the steel foundry testified that 6½ lbs. vanadium (alloy about one-third pure) was placed in each pot of 1,600 lbs. steel, which would amount to from 0.15 per cent to 0.16 per cent (calculation shows 0.1354 per cent); that vanadium put into castings varies from 0.05 per cent to 0.15 per cent, sometimes higher if it is ordered higher; also that the amount of ferrovanadium lost in the melt varies a good deal with the temperature of the steel, from nothing up to one-half of one per cent. A chemist stated that he found the vanadium content of the castings to be 0.03 per cent and 0.04 per cent; carbon content, 0.375 per cent and 0.384 per cent. A metallurgist stated that the addition of 6½ lbs. of ferrovanadium (33⅓ per cent vanadium) to 1,600 lbs. of steel would be equivalent in round numbers to 0.14 per cent vanadium, and that there would be at least 20 per cent, and possibly 30 per cent, of that lost. The result would be about 0.10 per cent vanadium remaining in the steel. He stated further that there is a recognized 'standard vanadium steel' not less than 0.15 per cent of vanadium, and that castings containing only 0.03 per cent and 0.04 per cent would not be castings of 'standard vanadium steel,' and that the two castings in question showed numerous gas cavities and blowholes. Three other witnesses testified that after the castings were broken they observed numerous holes.

"Notwithstanding the foregoing testimony as to the vanadium content and defects of the castings, a decision was given for the plaintiff."

It is evident from the above, and from numerous other instances, that might be cited, that a simple name is rarely a sufficient specification for any fundamental element, be it material or process; and it is therefore necessary to prepare a specification in which the limiting qualifications shall be given which will assure a material or process fully satisfactory for uses and purposes for which it is to be used.

§ 183. **Unsatisfactory Detailed Specifications.**—The difficulties of preparing specifications in detail for any material is illustrated by the recent serious trouble with "brass" and "bronze" in connection

³ Eng. News, Vol. 74, pp. 946-7.

with the work on the Catskill aqueduct. Iron and steel when exposed to moisture rapidly corrode and working parts are soon destroyed or rendered useless. To overcome this difficulty manufacturers of apparatus and material which are exposed to such conditions, and the engineers who use such apparatus and materials, have long sought an incorrodible material of moderate price and of sufficient strength to withstand these conditions. In general, alloys of copper with zinc, tin, nickle, aluminum, etc., in many combinations have been used for such purposes to greater or less extent for many years.

There has probably been no single piece of engineering construction on which such large quantities of such materials have been used as in the Catskill aqueduct where the total has amounted to nearly three million pounds. This consisted of castings and forgings, the former ranging from small pieces to pieces of 22,000 pounds, while the forgings ranged from small bolts, to stems for valves and sluice gates in some cases six inches in diameter and over thirty feet in length. The principal specifications issued by the board of water supply and covering this material, are as follows:

BRONZE CASTINGS

"All bronze castings shall be made of new metal, shall be free from objectionable imperfections and shall conform accurately to patterns. When the castings are being machined, if the metal shows signs of imperfect mixing, they shall be rejected. Unless otherwise called for in the specifications, or upon the drawings, bronze where indicated upon the drawings shall mean "manganese bronze."

MANGANESE BRONZE

"All manganese bronze shall be equal to Spare's, Parsons' or Hyde's manganese bronze, and shall have a tensile strength of not less than 45 per cent. of the ultimate tensile strength and an elongation of not less than 25 per cent.

BRASS RIVET ROD

"Tensile strength of brass rivet rods shall be not less than 55,000 pounds per square inch. The elastic limit shall be not less than 30,000 pounds per square inch, and the elongation not less than 20 per cent.

STEMS

"The main gate stem shall be of manganese bronze, or other bronze of approved composition, of such dimensions that when placed in tension under a load in pounds equal to the area of the valve opening in square inches multiplied by 125, the minimum cross-section of the stem shall have a resultant unit stress not exceeding two-thirds the elastic limit of the material used. These stems shall be turned straight and true and shall have all threads lathe-cut.

ROLLED BRONZE

“Whenever the term “bronze” is used in these specifications in a general way, or on the drawings, without qualifications, it shall mean manganese or vanadium bronze, or monel metal. Whenever the characteristics of any material are not particularly specified, such material shall be used as is customary in first-class work of the nature for which the material is employed.

“The minimum physical properties of bronze shall, except as otherwise specified, be as follows:

CASTINGS

Ultimate tensile strength.....	65,000 lb. per sq. in.
Yield point	32,000 lb. per sq. in.
Elongation	25 per cent.

ROLLED MATERIAL

Ultimate strength	72,000 lb. per sq. in.
Yield point	36,000 lb. per sq. in.
Elongation	28 per cent.

ROLLED MATERIAL, THICKNESS ABOVE ONE INCH

Ultimate strength	70,000 lb. per sq. in.
Yield point	35,000 lb. per sq. in.
Elongation	28 per cent.

“After being forged into a bar, rolled or forged bronze shall stand, first hammering hot to a fine point; second, bending cold through an angle of 120 degrees to a radius equal to the thickness of the bar.”

While some trouble was experienced with bronze pipes the principal difficulties were due to defects in large plates and in bolts, rods, side bars and ladder rungs. Many of these defects developed prior to installation where the material had been in storage for a considerable time. These defects consisted of cracks, sometimes very fine and only superficial while others were open and penetrated deeply into the material. In some cases such defects did not develop for two or three years after the material had been received and after the tests had indicated that the material was entirely satisfactory. Even the use of hot rolled rods and of thoroughly annealed cold rolled material supposedly free from initial stresses was not universally successful.

“The trouble with brass or bronze experienced on the Catskill aqueduct may be classified as follows:

“First: Breaks from stresses—

- a. Initial stresses due to methods of manufacture of the fabrication.
- b. Applied stresses due to use.

“Second: Damage by wrong heat treatment as in forging, bending, flanging, upsetting and annealing. * * *

"Seemingly both makers and users have misinterpreted the results of the usual standard laboratory test from lack of knowledge of characteristics of the copper alloys not revealed by tests. * * *

"As these investigations have proceeded, it has become evident that the engineers' present necessity is not merely an explanation of certain failures of brass but a fundamental knowledge of the physical characters and capacities of this group of alloys, knowledge which will be a safe and dependable guide in their manufacture and use."¹

The difficulty on the Catskill aqueduct has raised the question not only of proper specifications for the material but of the responsibility of the contractors who have furnished the same. Neither of these questions have been settled at this date.

In addition to the specifications above given, the contract further stipulates that:

"Inspection of the work shall not relieve the contractor of any of his obligations to fulfill his contract as herein prescribed, and defective work shall be made good and unsuitable materials may be rejected notwithstanding that such work and materials have been previously overlooked by the engineer and accepted or estimated for payment. If the work or any part thereof shall be found defective before the final acceptance of the whole work, the contractor shall forthwith make good such defects in a manner satisfactory to the engineer."

The specifications also state that:

"He shall complete the entire work to the satisfaction of the board and in accordance with the specifications;"

also

"all the work, labor and material to be done and furnished under this contract shall be done and furnished strictly pursuant to and in conformity with the attached specifications and the directions of the engineer."

To what extent the contractors should and can be held liable under their contract for defective materials furnished which were carefully inspected; tested and accepted and in which defects were developed so long after their manufacture and acceptance, is a serious and important question and involves in this instance a liability for a very large expense which must be sustained either by the city or by the contractor.

Difficulties with similar materials have been experienced in connection with the Minneapolis filter plant, the work on the Panama Canal, and in the U. S. Navy. It is quite possible that many of the difficulties

¹ Brass in Engineering Construction by A. D. Flinn, Deputy Chief Engineer, Board of Water Supplies, City of New York. Proceedings of the Municipal Engineers of the City of New York.

which have occurred in the use of this material have been due to commercial competition rather than to the lack of knowledge and experience among manufacturers, and it is probable that the best manufacturers would be ready at suitable prices to fabricate these materials to meet all reasonable requirements and to give suitable guarantees to this effect. It is doubtful however if such results can be obtained in open competition.

§ 184. **Basis of Correct Specifications.**—From the discussion in the two previous sections it is evident that the preparation of specifications suitable to assure proper results is often attended with great difficulties and much uncertainty, and that there is no rule universally applicable for their preparation. In the actual preparation of specifications much will depend on the conditions under which they are to be prepared. If the quantities involved are small and the function of the material unimportant, the preparation of an elaborate specification even when possible is hardly desirable as materials of commercial quality will probably be entirely satisfactory and either the risk or cost of replacement is not large and may readily be taken. As the quantities and importance increase, the necessity of greater care to secure correct specifications also increases, and the question as to how the character of the work or material can be controlled and the desired results secured become extremely important.

Every material has certain physical and chemical properties among which may be some or all the following:

Physical Properties.—

Size, shape and dimension.

Color, transparency, general appearance and appearance of fracture.

Uniformity, homogeneity and absence of apparent defects.

Specific gravity or relative weight, density and porosity.

Properties of physical combination (as alloys, etc.).

Physical composition.

Hardness and elasticity.

Strength (tension, compression, torsion or impact).

Physical conditions under manipulation or as a result of manufacture of working into form for use. (Finish, defects, flaws, structural stresses, etc.)

Calorific Qualities.—

Melting and boiling points

Specific heat.

Conductivity.

Cubical and linear expansion.

Heating value (fuels).

Electrical Properties.—

Specific resistance.

Relative conductivity.

Chemical Properties.—

Atomic weight.

Chemical composition.

Chemical combination.

Chemical impurities.

Corrodibility.

Some or all of the above properties may in some forms have an important effect on the quality of the material needed for the particular use to which it is to be applied. These effects however are not always known or appreciated although certain qualities may be very essential and easily determined, while others are approximately understood and may be correspondingly helpful in the selection. These properties may be determined by *inspection* which, however, involves judgment and experience and will therefore differ in results with the individual, and standard *tests* which are far more exact when made by men of even limited experience but who are familiar with the various physical and chemical manipulations on which such tests are based. The limitation of these qualities by specifications are useful only when the effect of such qualities on the value of the material for any particular case is known, and where such value is unknown other methods of control are necessary.

In the preparation of specifications for all materials and all processes, workmanship, manufactured articles, machines or structures, the control of the desired results may be effected in one or more of the following ways, which are however more or less directly related; namely:

1. By composition or properties, and manipulation or workmanship.
2. By inspection.
3. By tests.
4. By guarantees.
5. By selecting those successfully used under similar conditions.
6. By requiring the equivalent of a selected standard.

§ 185. **Composition or Proportion and Manipulation or Workmanship.**—It is frequently the case that a specified composition of known material will give the results desired. For example when ce-

ment is furnished a contractor and satisfactory sand and gravel are available, the specification for concrete need include only its composition and method of manipulation. No tests are usually admissible for the results of the tests will necessarily be controlled by the composition and manipulation. In the same manner machinery bearings may be controlled by a requirement for certain definite alloys known to be satisfactory for similar service, and a certain specified grade of workmanship. In both cases and shape and dimensions must be fixed by the design.

§ 186. **Inspection.**—Where considerable experience is available it has commonly been ascertained that a certain appearance or the possession of certain qualities which can be determined by inspection, more or less clearly indicate the suitability of the material for the requirements of a particular use. Appearance, finish and workmanship must be determined in this way, in any event, although the character of finish and of workmanship can and should be so defined as to indicate whether ordinary or extraordinary requirements are demanded.

Uniformity, homogeneity and the absence of apparent defects must all be determined by inspection. Various building materials such as lumber, brick, stone, etc., not subject to great stresses, are accepted or rejected on inspection, the inspection defining their general character; the material of the lumber and the limitations of its imperfections in accordance with commercial standards, the general character of the brick and the extent to which defects will be admitted, and the general character and size of the stone.

In all such cases the inspector needs previous experience under the direction of others who are familiar with these various materials and their manipulation in practical construction, otherwise he may admit unsatisfactory workmanship and material or impose undue hardships on the contractor.

§ 187. **Tests.**—When a detailed knowledge of the effect of various qualities is available, the control of work and material by means of recognized standard tests is the most desirable. In such cases the current knowledge of these qualities and characteristics may be insufficient to permit the preparation of specifications which will result in the furnishing of satisfactory material, as in the case of the brass in the Catskill aqueduct; but the best knowledge available will either have to be used and the risks of the results taken unless a sufficient investigation is made to determine the real qualifications which must be possessed by the material in order to render it satisfactory. Investigations of this

kind are inexpedient unless the quantity of material is so large as to warrant the expense involved and the time during which the material is to be used is sufficiently long that suitable researches can be made. Such tests are constantly being made in the laboratory of the Pennsylvania Railroad Company at Altoona, Pa., and in the laboratories of various large manufacturing companies and of various universities. Usually however extended investigations are inexpedient on most engineering works.

In general the various qualities required must be susceptible of some method of determination, test or measurement. Certain qualities for example may be determined as follows :

Quantity by number, weight or measurement.

Strength by tension, compression, torsion or impact tests.

Composition by chemical or mechanical analysis.

Duty, efficiency, heat value and power consumption by tests.

Resistance to conductivity, as in the case of electricity, light, heat, etc., by specified tests.

§ 188. **Guarantees.**—It is evident that a material, machine or structure may be properly controlled after its quantity, capacity or dimensions have been satisfactorily established, by a quittance guarantee from the manufacturer or contractor that he will replace all or any part or portion of the same which may prove defective within a certain definite period or if it fails to give certain results and without other definite requirement. Guarantees are not always satisfactory to the purchaser because they do not assure satisfaction where failures do occur, and the delay and expenses of replacement are such that in many cases, that which is not fully satisfactory will be accepted rather than undergo the annoyance, delay and expense of having to remove work which has been done and again replacing it with possibly little better results. Guarantees to be of value must be carefully drawn and must cover all contingencies in such a manner as to fully protect the purchaser and yet inflict no undue hardship on the manufacturer or contractor. It is evident that guarantees which will cover a long period of use are difficult and expensive to secure and equally difficult to enforce. The manufacturer hesitates to give a guarantee for a considerable period of time because of the trouble and expense which may be involved and because of the uncertainties as to the actual treatment of his material, apparatus or machine in connection with the work for which it is to be furnished. The cause of failure in a material or machine which has failed after several years' use is often questionable.

Is the failure due to faulty material or to faulty use? The facts are difficult to determine and still more difficult to prove, and the manufacturer naturally refuses to take the risk unless compensation for the same is unduly great from the standpoint of the user. For this reason long time guarantees are as a rule impracticable to secure, although in general such guarantees will be made for a period covering the time of inspection tests and construction as in the Catskill aqueduct case previously cited. Further than that it is usually inexpedient to go and the user must either take the risk or pay an excessive price.

§ 189. **Successful Use.**—In many cases materials, machinery, etc., may be selected on the basis of satisfactory results of actual experience under similar conditions of use. In such cases competition may be secured by including the products of several different manufacturers who are known to furnish satisfactory goods. In such cases the letting cannot be left open to general competition on the basis of minimum price, as new or unknown goods may be proposed concerning which no adequate information is available. No better method for the selection of many articles is available than that based on long and successful use under a considerable range of conditions. It is important, however, to determine that the conditions of use are comparative and that the present quality of the material or article as now offered is fully equal to that on which the experience is available.

§ 190. **By Comparison with a Standard.**—Materials, supplies and manufactured articles and the results of fundamental construction may also be controlled by comparison with standards more or less definite and which must consist of similar articles known to be satisfactory. The comparison with such standards must be gaged by tests or inspection. Take for example the hardware fittings, locks, hinges, etc., for the doors of a large and important building. These will seldom be made to design but will usually be selected from the manufacturer's catalog. They may vary from the simple work done by local blacksmith to the artistic bronze production of the highest grade. Under the conditions of the work only certain limitations are possible. Hinges may be required of certain material and of certain dimensions; to some extent, finish may be prescribed. Even these must be kept within the limits of designs actually available in order to keep the expense within limits. The design, unless special and this is seldom practicable, must be selected from the catalogs of manufacturers and can be specified only as a certain design of a certain company, or the equal thereof. This method is evidently unsatisfactory as it gives a great ad-

vantage to a single manufacturer whose goods are thus directly stated to be satisfactory, and therefore when this method must be used, as it must frequently with goods similar to the hardware named above, two or more comparative standards from different manufacturers should be named, if practicable.

In general when the preparation of specifications for special or proprietary articles is contemplated, it is frequently desirable to correspond directly with several leading manufacturers and ascertain what specifications they will meet and what guarantees they will agree to furnish. Without such correspondence, the preparation of specifications with certain definite requirements and certain fixed guarantees satisfactory to the purchaser, is apt to give barren results through the refusal of the manufacturer to bid under the conditions named. A contract is the meeting of the minds of the two parties involved, and frequently bids can be obtained only by consultation with all parties interested.

§ 191. **Investigation of Materials.**—In preparing specifications for materials or other fundamental elements of construction, the engineer is cautioned against the unintelligent copying of similar specifications prepared by others for possibly quite different conditions.

The engineer is advised when preparing such specifications to investigate thoroughly and in detail the materials or other elements which are to be used, before specifications for the same are prepared. The investigation should include such of the following factors as may be pertinent:

1. Occurrence.
2. Properties.
3. Use or application.
4. Processes of manufacture.
5. Manufacturers, dealers, etc.
6. Methods of use.
7. Current prices.
8. Reference to sources of information.

(See "Notes on Aluminum" sec. 193.)

The engineer should also consider and determine what properties should be limited, and the commercial limitations which should be specified. The limitations imposed should not exceed practicable limits, and should be only those reasonably desirable or actually essential for the purpose in view. Such information is often contained in the discussion of technical societies, in technical journals, in reference books and special treatises, and in specifications prepared for similar purposes.

On unfamiliar subjects, such limitations should usually be determined from more than a single source.

Not all of the qualities or characteristics of a material are to be described in the specifications but only such as may so vary in the commercial product as to render the material unsuited for the purpose for which it is to be used. A knowledge of such limitation is not common to engineers but is usually possessed only by those who are familiar with the material in a practical way. After a material is in such general and common use and is of such great importance that its necessary limiting qualities have received much attention and have been discussed before technical societies and in the technical press, often in such cases the engineer unfamiliar with its detailed use can, by study and investigation, ascertain the necessary limitations with sufficient exactness for the purpose of specification writing.

In other cases, a material may have a more or less local character or may be in the process of change, and the desirable or practical limiting characteristics may be more difficult to determine and specify. An investigation of the material, inquiring of those parties familiar with its production and use, will usually give the required information.

It is in general undesirable and impracticable uniformly to require the best of every material, for such specifications will involve great and unnecessary expense. The material should have the qualities needed for the place and under the circumstances in which it is to be used, no greater or no less. A greater requirement involves useless expense; a less requirement involves improper materials.

After the investigation is completed, an outline should be prepared of the special requirements necessary for the specific uses for which the material or element is needed (see Sections 194 and 199), after which the specifications can then be prepared.

In the preparation of such specifications, it is equally important:

First: To include all requirements of quality or workmanship needed to secure the results desired, and

Second: To omit any unnecessary requirements or restrictions, either of quality or workmanship, in order to avoid unnecessary expense.

The system, if carefully carried out, will result in the thoughtful consideration and preparation of specifications, which is essential for the best results, and will eliminate the thoughtless copying of erroneous specifications. When a set of specifications has once been pre-

pared in this way, the notes should be retained for future reference and can occasionally be brought up to date. It will not be necessary to repeat this process with each rewriting of similar specifications; and after wide experience with certain materials or elements, even reference to the notes may become unnecessary. The same system can, however, be used to advantage whenever the practicing engineer is called upon to prepare specifications for material or elements of construction, concerning which his experience is limited.

§ 192. **Conclusions of Dr. Dudley.**—Dr. Chas. B. Dudley, in his Presidential address to the American Society for Testing Materials, at its annual meeting in 1903, summarizes his conclusions in regard to the making of specifications for materials as follows:

1. "A specification for material should contain the fewest possible restrictions, consistent with obtaining the material desired.

2. "The service which the material is to perform, in connection with reasonably feasible possibilities in its manufacture, should determine the limitations of a specification.

3. "All parties whose interests are affected by a specification should have a voice in its preparation.

4. "The one who finally puts the wording of the specification into shape, should avoid making it a place to show how much he knows, as well as a mental attitude of favor or antagonism to any of the parties affected by it.

5. "Excessively severe limitations in a specification are suicidal. They lead to constant demands for concessions, which must be made if the work is to be kept going, or to more or less successful efforts of evasion. Better a few moderate requirements rigidly enforced, than a mass of excessive limitations, which are difficult of enforcement, and which lead to constant friction and sometimes to deception.

6. "There is no real reason why a specification should not contain limitations derived from any source of knowledge. If the limitations shown by physical test are sufficient to define the necessary qualities of the material, and this test is simplest and easiest made, the specifications may reasonably be confined to this. If a chemical analysis or a microscopic examination, or a statement of the method of manufacture, or information from all four, or even other sources, are found useful or valuable in defining limitations, or in deciding upon the quality of material furnished, there is no legitimate reason why such information should not appear in the specifications. Neither the producer nor the consumer has a right to arrogate to himself the exclusive right to use information from any source.

7. "Proprietary articles and commercial products made by processes under the control of the manufacturer cannot, from the nature of the case, be made the subject of specifications. The very idea of a specification involves the existence of a mass of common knowledge in regard to any material, which knowledge is more or less available to both producer and consumer. If the manufacturer or producer has opportunities, which are not

available to the consumer, of knowing how the variation of certain constituents in his product will affect that product during manufacture, so also does the consumer, if he is philosophic and is a student, have opportunities not available to the producer, of knowing how the same variation of constituents in the product will affect that product in service, and it is only by the two working together, and combining the special knowledge which each has, that a really valuable specification can be made.

8. "A complete workable specification should contain the information needed by all those who must necessarily use it, in obtaining the material desired. On railroads this may involve the purchasing agent, the manufacturer, the inspector, the engineer of tests, the chemist, and those who use the material. A general specification may be limited to describing the properties of the material, the method of sampling, the amount covered by one sample, and such descriptions of the tests as will prevent doubt or ambiguity.

9. "Where methods of testing or analysis or inspection are well known and understood it is sufficient if the specification simply refers to them. Where new or unusual tests are required, or where different well-known methods give different results, it is essential to embody in the specification, sufficient description to prevent doubt or ambiguity.

10. "The sample for test representing a shipment of material should always be taken at random by a representative of the consumer.

11. "The amount of material represented by one sample can best be decided by the nature of the material, its importance, and its probable uniformity, as affected by its method of manufacture. No universal rule can be given.

12. "The purchaser has a right to assume that every bit of the material making up a shipment, meets the requirements of the specification, since that is what he contracted for and expects to pay for. It should make very little difference, therefore, what part of the shipment the sample comes from, or how it is taken. Average samples made up of a number of subsamples, are only excusable when the limits of the specification are so narrow that they do not cover the ordinary irregularities of good practice in manufacture.

13. "Retests of material that has once failed should only be asked for under extraordinary conditions, and should be granted even more rarely than they are asked for, errors in the tests of course excepted.

14. "Simple fairness requires that when it is desired that material once fairly rejected should nevertheless be used, some concession in price should be made.

15. "Where commercial transactions are between honorable people, there is no real necessity for marking rejected material, to prevent its being offered a second time. If it has failed once, it will probably fail a second time, and if return freight is rigidly collected on returned shipments the risk of loss is greater than most shippers will care to incur. Moreover, it is so easy for the consumer to put an inconspicuous private mark on rejected material, that it is believed few will care to incur the probable loss of business that will result from the detection of an effort to dispose of a rejected shipment by offering it a second time.

16. "All specifications in actual practical daily use need revision from time to time, as new information is obtained, due to progress in knowledge, changes in methods of manufacture, and changes in the use of materials. A new specification, that is one for a material which has hitherto been bought on the reputation of the makers and without any examination as to quality, will be fortunate if it does not require revision in from six to ten months, after it is first issued.

17. "In the enforcement of specifications, it is undoubtedly a breach of contract legitimately leading to a rejection, if the specified tests give results not wholly within the limits, and this is especially true if the limits are reasonably wide. But it must be remembered that no tests give the absolute truth, and where the results are near, but just outside the limit, the material may actually be all right. It seems to us better, therefore, to allow a small margin from the actual published limit, equal to the probable limit of error in the method of testing employed, and allow for this margin in the original limits, when the specifications are drawn.

18. "Many producers object to specifications on the ground that they are annoying and harrassing, and really serve no good purpose. It is to be feared that the complaint is just, in the cases of many unwisely drawn specifications. But it should be remembered that a good reasonable specification, carefully worked out, as the result of the combined effort of both producer and consumer, and which is rigidly enforced, is the best possible protection which the honest manufacturer can have against unfair competition.

19. "Many consumers fear the effect of specifications on prices. Experience seems to indicate that after a specification has passed what may be called the experimental stage, and is working smoothly, prices show a strong tendency to drop below figures prevailing before the specification was issued.

20. "A complete workable specification for material represents a very high order of work. It should combine within itself the harmonized antagonistic interests of both the producer and the consumer, it should have the fewest possible requirements consistent with securing satisfactory material, should be so comprehensive as to leave no chance for ambiguity or doubt, and above all should embody within itself the results of the latest and best studies of the properties of the material which it covers."

§ 193. Example of Investigation.

NOTES ON ALUMINUM—SYMBOL AL.

Nature—Metal—

Occurrence—Alumina, Al_2O_3 , gives the characteristic qualities to Argillaceous rock formation of which the slates and shale are familiar examples.

Hardness (Moh's), 3.

Physical Properties—

Specific gravity—a. Cast, 2.55.

b. Wire (conductors), 2.68.

c. Rolled, 2.75.

Relative specific gravity (compared with copper) wire, 0.30.

Atomic weight, 27.1.

Melting point, 1157° F. commercial wire.

Melting point, 1150° F. pure aluminum.

Specific heat mean (0 to 100° C.), 0.22.

Thermal conductivity mean (0 to 100° C.), 0.48.

Coefficient of cubical expansion (0 to 100° C.), .00007.

Coefficient of linear expansion per deg. F., .0000127 wire.

Coefficient of linear expansion per deg. C. .0000231 wire.

Pure cast aluminum tensile strength about 18,000#/sq. in.

Tensile strength (wire), 20,000 to 35,000#/sq. in.

Elastic limit—one-half ultimate strength.

Modulus of elasticity, 7,500,000#/sq. in.

Electrical Properties—

Specific Resistance, 0° C.

In microhms per cm. cube, 2.6 to 3.0.

In ohms per mil-foot, 15.6 to 18.0.

Temperature coefficient per deg. C., 0.36 per cent.

Relative conductivity (copper = 100), 62.

Relative conductivity for equal size copper (soft copper = 1), .61 to .63.

Relative weight for equal size of copper (soft copper = 1), 0.33.

Relative weight for equal length and resistance of copper (soft copper = 1), 0.48.

Notes on Properties—

Aluminum is a white malleable metal of low specific gravity. On account of its softness, it is for many purposes alloyed with iron, copper, tin or zinc. Its common impurities are silicon and iron. Under ordinary conditions aluminum may be considered as quite non-corrodible. It is affected, however, in the oxides of some atmospheres, namely, near salt water or where the air contains oxides of sulphur. Hydrochloric acid is the best solvent, and strong solutions of caustic alkalis readily dissolve it.

Uses—

Aluminum has large application for electrical conductors where insulated conductors are unnecessary. The increase in cost of insulating the larger aluminum wire, together with the difficulty in making soldered connections, has prevented its wide use as insulated conductors. Owing to the greater coefficient of expansion over that of copper, the sag allowed in stringing aluminum wire must be greater than that used in copper wire lines. It is common to make aluminum transmission lines of cable formed of aluminum wires, around a core of high elastic limit steel, in order to do away with the excessive sag.

In making castings under ordinary conditions, a shrinkage of 3/16 inch per foot should be allowed.

Aluminum is very "hot short" just before solidifying in the mould.

Alloys—Aluminum can be hardened and strengthened by a small quantity of copper. About 3% of copper doubles the tensile strength and increases the specific gravity from 2.67 to 2.85. Rolled bronze bars made up of 90% copper and 10% aluminum have tensile strength of

100,000# per square inch, elastic limit of 60,000# per square inch and elongation of 10%.

Thermit Process of Welding—

This process depends upon the affinity existing between finely divided aluminum and iron oxide. When an intimate mixture of these materials is ignited, the temperature raises to about 5400°, and white hot fused iron results. The chemical reaction of this process is

$$\text{Al} + \text{Fe}_2\text{O}_3 = \text{Al}_2\text{O}_3 + \text{Fe}.$$

Aluminum is used in steel manufacture to prevent the retention of gases within the steel, and thus produce a solid ingot. It also increases the fluidity of steel and thus tends to produce sharper castings.

Manufactured by The Aluminum Company of America, Pittsburg, Pa.

Current Prices—

Cable No. 0—in large quantities—(Dec. 1913) Steel Core.—144.7# per 1,000 ft. 6 strands #1,327 B. & S. gauge, 18 cents per lb.

Tie wire—No. 2, in small quantities (1912), 25 cents per lb.

Aluminum tubing—iron pipe sizes (Jan. 9, 1914):

1/8" diameter, 58 cents per lb.

1/4" diameter, 54 cents per lb.

3/8" diameter, 48 cents per lb.

1/2" diameter, 48 cents per lb.

3/4" diameter, 46 cents per lb.

1" diameter, 45 cents per lb.

Price of tubing varies greatly with gauge—

Tubing 1/4" outside diam. #18 Stub's gauge, \$1.09 per lb.

Tubing 1/4" outside diam. #25 Stub's gauge, \$2.29 per lb.

Tubing 1" outside diam. #18 Stub's gauge, 49 cents per lb.

Tubing 1" outside diam. #25 Stub's gauge, \$1.09 per lb.

Aluminum castings (Jan., 1912)—

Transmission line saddles, wt. 2 3/4 oz. each, 50 cents per lb.

Transmission line saddles, wt. .6 oz. each @ 3.2 cents each, 86 cents per lb.

Rolled plate (Jan., 1912) for use in clamps on transmission cable, sheared and bent sleeves, 1 3/4 oz. each @ 5 cents each, 45 cents.

REFERENCES.

Am. Civil Engrs.' Pocket Book.

Aluminum for Electrical Conductors (Handbooks of the Aluminum Co. of America, Pittsburg, Pa.).

Handbook of Standard Underground Cable Co., Pittsburg, Pa.

Inspectors' Pocket Book. Byrne.

Coal Miner's Pocketbook, McGraw-Hill Book Co.

Kent's Mechanical Engineers' Pocket Book.

Year Book, American Soc. Testing Materials, 1910.

§ 194. Outline of Specifications for Aluminum Wire.
Material.

Surface conditions.

Package sizes.

Protection in handling.

Method of calculating weights, etc.

Sizes and variations allowable.

Strength.

Electrical conductivity.

§ 195. Specifications for Aluminum Wire.

(After Am. Soc. Test. Materials. Year Book 1910, p. 98).

1. The material shall be aluminum of such quality that it shall have the properties and characteristics here specified.

2. The wire shall be free from all surface imperfections not consistent with the best commercial practice.

3. Package sizes for round wire and cables shall be agreed upon in placing individual orders.

4. The wire shall be protected against damage in ordinary handling and shipping.

5. For the purpose of calculating weights, cross sections, etc., the specific gravity shall be taken at 2.68.

6. The size shall be expressed as the diameter in decimals of an inch. Permissible variations from the nominal diameter shall be:

(a) For wire, .10 inches in diam. and larger, 1 per cent either way.

(b) For wire smaller than .10 in. 1 mil. either way.

7. The wire shall be drawn so that the tensile strength will not be less than 20,000# per sq. in., the elastic limit not less than 50 per cent of the ultimate strength, and the percentage of reduction in area of 50.

8. Electrical conductivity shall be determined upon fair sample by measurements of resistance, and the resistance shall not exceed 18.0 ohms per mil.-foot at 0°C.

§ 196. Assignment on Fundamental Material and Supplies.

The student should select one or more of the following subjects, and first: Investigate the subject in considerable detail and prepare a report on the same. (See sec. 193); second: Outline the practicable limitations as to the qualities and such other requirements as should be included in a specification for the material for the use to which it is to be applied. (See sec. 194); and third: Prepare or select specifications which will form the basis for an intelligent bid and contract for such material. (See sec. 195.)

For looking up these various subjects references are given at the end of the Chapter and in the Bibliography at the end of the volume.

This list of materials is by no means complete, and other similar subjects having a local importance can often be substituted to advantage.

So far as possible the use for which a material is suggested to be applied is placed opposite the "kind" of material. In many cases, however, the various kinds of material mentioned can be applied to several or all of the various uses suggested.

It will usually be desirable to specify more definitely the exact use for which the material is desired. In doing this the specification should be given a local significance by making it apply to some local use, the conditions of which can be investigated and considered by the student.

Material or Supplies	Kind	For
Asphalt		Paving, Water Proofing or Roofing
Asbestos	Wool or Cellular Paper	Pipe Covering Paper Sheets for fire protection
	Compressed	Shingles
	Board	Insulating Barriers or Wire Cover- ing
Babbitt Metal		Machine Bearings
Belts	Cotton Leather or Rubber	Power Transmission
Brass	Castings	Machine Bearings & Valve Bodies
	Wire	Spring
	Sheet	Gateways Guides and Bearings
	Pipe	Railing and condenser tubes
	Rods	Lightning arrester horn gaps
Brick	Common	Building, Boiler Setting or Founda- tions
	Face or Pressed ..	Sewers, Manholes or Catchbasins
	Dry Pressed or Re- pressed	Building Fronts
	Fire	Building Fronts
	Sand Lime	Boiler Setting
	Paving	Buildings
	Radial	Street Paving
	Enameled	Arches in Buildings
Bronze	Aluminum	Interior Walls of Buildings
		Condenser Plates
		Bolts below Tide Water
		Small Castings
	Manganese	Propeller Blades
	Phosphor	Pinions, Machine Bearings or Main Shafting
		Bolts and Nuts in Water Cylinders
	Tobin	Condenser Plates or Hull Plate for Ships
		Shafting for Ships or Deck Fittings
Brush	Willow	Bolts
Carborundum ...	Abrasive	Mattresses, and other river revet- ment work
Carbon		Emery Wheels or Emery Powder
		Arc Lights or Batteries
		Rheostats or Commutator Brushes
Cement, Portland		Concrete or Mortar
Coal		Fuel for Heat or for Boiler
		Gas Manufacture or Producer Gas
Clay		Laying Fire Brick or Puddle

Material or Supplies	Kind	For
Clay Goods	Sewer Pipe	For Sewers
	Drain Tile	For Farm Drainage
	Terra Cotta	Ornaments of Buildings
	Fire Proofing.....	Columns in Buildings or Floors in Buildings
Copper	Castings	Switches
	Wire	Electric Transmission
	Sheet	Roofs
	Pipe	Still
Cork		Friction Clutches or Heat insulation
		Life Preservers or Carpets
Flagstones		Walks, Curbs or Gutters
Glass	Rolled Plate	Windows
	Wire	Fire proof Windows
	Common	Windows or Insulators
Graphite		Lubricant or Crucibles
Gravel		Commutator Brushes or Rheostats
		Roofing, Roads, Concrete or Filter Drains
Gas	Water, Coal, Pro- ducer or Natural	Power, Fuel or Light
Gasoline		Power or Fuel
Hose	Cotton or Rubber .	Fire Protection
Iron	Malleable	Castings
	Cast	Castings, Pipes, Machinery
	Corrugated	Roofs or Walls
	Galvanized	Roofs, Tanks or Towers
	Wrought	Pipes, Structural Shapes or Boiler Plate
Lead	Castings	Window Weights
	Drawn	Pipe
	Pig	Pipe Joints
	Sheet	Lining Tanks
	Wool	Pipe Joints
Leather		Belts, Belt Lacings or Harness
Limestone		Lime, Calcium Carbide or Buildings
Lime		Plaster or Mortar
Linseed Oil		Paint Vehicle
Marble		Buildings, Floors or Stairways
		Wainscoting or Switchboards
Oil	Crude	Roads, Concrete or Timber Preserv- ation
	Fuel	Locomotive or Boiler
	Light	Kerosene
	Lubricant	Cylinder
	Paint Vehicle.....	Linseed
	Insulating	Transformers or Oil Switches
	Hemp	Steam Valve Stems
	Cotton	Water Valve Stems
Packing	Rubber	Pump Piston Rings
	Composition	Engine Piston Rings
	Leather	Pumps
	Metal	Pipe Joints
		Building outside or inside
Plaster		Polishing
Pumice Stone ..		Power Transmission
Rope	Manila	Hoisting Cable
	Hemp	Derrick Guys
	Wire	Cement or Painting
Red Lead		Belting, Insulation or Matting in Power House
Rubber		Valves or Packing
Sand		Concrete, Mortar or Filter
		Plastering or Moulding

Material or Supplies	Kind	For
Sandstone		Curbing or Building
Stone	Rubble	Riprap, Concrete Backing for masonry or Foundations. light buildings
	Squared	Sidewalks, Gutters or Curbing Street Paving or Bridge Masonry Foundations—heavy buildings
	Cut Stone	Building Walls
	Rough Pointed	Foundations—very heavy
	Fine Pointed	Bridge Masonry
	Crandalled	
	Cross-Crandalled ..	Arch Masonry
	Tooth-axed	Door Sills
	Bush Hammered ..	Steps
	Rubbed	Aqueducts
Slate		Roofing, Floors or Blackboards Switchboards or Barriers
Steel	Fire Box	Locomotive Fire Boxes
	Boiler	Boilers
	Flange	Boiler Heads
	Ship	Hull Plates
	Tank	Tanks
	Rivet	Rivets
	Nickel	Solid and Hollow Forgings for heavy shaftings
	Structural	Bridge or Roofs
	Rails	Railroads
	Reinforcing Bars ..	Concrete Work
	Pipe	Steam Pipes
	Castings	Gears
Timber	Douglas Fir	Bridge Timbers or Trestle
	Southern Pine	Cribs
	Hemlock	Sheeting
	Oak	Fence Posts or Railroad Ties
	Cedar	Transmission Poles or Paving Blocks
	Tamarack	Piles
	White Pine	Inside Finishing
	Maple	Flooring
		Frames, Joists, Rafters or Studding
		Sheeting or Shingles
		Clapboards or Shiplap
Tile	Vitrified	Roofing
	Fire Proof	Walls
	Book	Roof
		Floors or Building Blocks
		Chimney Blocks or Chimney Tile
	Glazed	Ornamental
Tin Plate		Roofing
Turpentine		Paint and Varnish Solvent
Wire	Hard Drawn Cop- per	Electric Distribution
	Soft Drawn Copper	Interior Electric wiring
	Insulated	
	Weather Proof	
	Copper Covered	
	Steel	Ground Wire
	Iron	Telephone
	Steel	Telegraph
	Barbed	Fences
	Meshed	Reinforcing Mesh for Concrete or Fences
Wrought Iron ...		Structural, Pipes or Boiler Plate
Zinc	Sheet	Lining Tanks

BIBLIOGRAPHY OF MATERIALS.

See "Engineering Index" and files of various technical societies listed therein. See also:

Mechanical Engineer's Pocketbook—Kent. John Wiley & Sons.

American Civil Engineer's Pocketbook. John Wiley & Sons.

Civil Engineer's Pocket Book—Frye. D. Van Nostrand Co.

Inspector's Pocket Book—Byrne. John Wiley & Sons.

Architect's and Builder's Pocket Book—Kidder. John Wiley & Sons.

Civil Engineer's Pocket Book—Trautwine. John Wiley & Sons.

A Manual of Civil Engineering—Rankine, 1885. Chas. Griffin & Co., London.

Notes on Building Construction, Part III. Materials. Riverton's, London, 1889.

Building Construction and Superintendence—F. E. Kidder. Wm. F. Comstock & Co., New York.

Materials of Engineering (in 3 parts)—Prof. Robt. H. Thurston. John Wiley & Sons.

Materials of Construction—J. B. Johnson. John Wiley & Sons.

Strength of Materials—H. E. Murdock. John Wiley & Sons.

Materials of Construction—Prof. G. B. Upton. John Wiley & Sons.

Materials of Engineering—Prof. Wm. H. Burr. John Wiley & Sons.

Materials of Construction—A. P. Mills. John Wiley & Sons.

The Principal Species of Wood—C. H. Snow. John Wiley & Sons, 1903.

Mechanical Properties of Wood—S. J. Record. John Wiley & Sons, 1915.

Brickmaker's Manual—R. B. Morrison. F. A. Randall & Co., Indianapolis, 1890.

Manufacture of Brick, Tiles and Terra Cotta—C. T. Davis. Henry Carey Baird & Co., Philadelphia, 1889.

Report on Compressive Strength, Specific Gravity, and Ratio of Absorption of Building Stones in United States to Chief of Engineers, U. S. Army. By Q. A. Gilmore. D. Van Nostrand Co., 1876.

Treatise on Masonry Construction—Prof. I. O. Baker. John Wiley & Sons.

Masonry—M. A. Howe. John Wiley & Sons, 1915.

Stones for Building and Decoration—Geo. P. Merrill. John Wiley & Sons, 1891.

Government and State Geological Survey Bulletins on Clays, Building Stones, etc.

Steel, A Manual for Steel Users—Wm. Metcalf. John Wiley & Sons, 1896.

Cast Iron, A Record of Original Research—Wm. J. Keep. John Wiley & Sons, 1903.

Reports of Tests of Metals and Other Materials for Industrial Purposes. U. S. Testing Machine at Watertown Arsenal, Mass.

Materials of Machines—A. W. Smith. John Wiley & Sons, 1915.

CHAPTER XVIII

SPECIFICATIONS FOR FUNDAMENTAL PROCESSES

§ 197. **Fundamental Processes.**—The fundamental processes of construction work should be investigated in very much the same manner as materials and supplies. The preparation of specifications for these processes if carried into detail is even more difficult than those for materials. In both materials and processes, improvements are constantly being made, and the methods employed are constantly undergoing changes and improvements. As a general rule, it is unwise to specify methods in detail, as results are the end desired and the detailed methods to be pursued should be designated only to the extent necessary to secure the results desired. If the methods to be pursued are fully specified, the contractor becomes a “servant” and not an “independent contractor,” and the principals may become liable for casualties which may occur and unsatisfactory results which may obtain on account of improper methods of procedure. As a general rule, the contractor should be left reasonably free to pursue those methods which his experience dictates, for it is largely on account of this experience that his services are secured. He should, however, be required to do those things or all those processes which are clearly known to be essential to secure proper results. As a general proposition, the specifications for an engineering process should include:

- I. A general description of the work to be done.
- II. Reference to plans, profiles, etc., provided.
- III. The material to be used. (Materials covered by another specification.)
- IV. The operations included.
- V. Precautions to be taken.
- VI. The results to be obtained.

§ 198. **Earthwork and Rock Work.**—Among the processes most common in engineering works is the excavation or construction of earth and rock works. Such works have many features in common, while other features may be special and peculiar to a particular work. For the purpose of the general study of specifications, all such works can be analyzed together. In using the analysis for the preparation of specifications, all specifications not applicable to the

case in hand should, of course, be omitted. In the same way it must be remembered that besides the headings given in the analysis, there are various other items in regard to the general character of the work, contingencies, delays, the hazards of construction, the furnishing of tools, plant, etc., which are usually included in the general form of agreement, but which may be included in the specification, if desired. In addition to these there may be special features which demand special treatment. While an attempt has been made to make the analytical form given as complete as practicable, it is offered simply as a basis or a general model for a special form to be prepared by the engineer for any special work he may have on hand.

§ 199. Analytical Division of Earth and Rock Work Specifications.

I. GENERAL DESCRIPTION :

- A.* Description.
- B.* Location.
- C.* Dimensions.
- D.* Form.
- E.* Grade.
- F.* Divisions of work.

II. MATERIAL :

- A.* General character, borings, soundings, etc.
- B.* Classification.
- C.* Quality of material to be used (in fills).
- D.* Quantities.
- E.* Measurements and estimates.
- F.* Shrinkage (in fills).
- G.* Extra excavation.
- H.* Extra material and borrow pits for fills.

III. OPERATIONS :

- A.* Beginning work.
- B.* Grades and lines.
- C.* Clearing, grubbing and wrecking.
- D.* Breaking surface or mucking.
- E.* Changes in roads, railroads, etc.
- F.* Consolidation, rolling, tamping and puddling.
- G.* Limits of work.
- H.* Bracing, shoring, and protection of work.
- I.* Protection of public, care and maintenance of traffic.

- J. Obstructions.
- K. Pumping and draining.
- L. System of excavation.
- M. Filling (methods of work).
- N. Drilling, channeling, blasting and quarrying.
- O. Disposal of material.
- P. Overhaul.
- Q. Leveling, grading and dressing.
- R. Sodding and seeding.
- S. Continuous prosecution of work.
- T. Maintenance.

§ 200. **General Description.**—Under this title are included various data descriptive of work which may be subdivided into (A) Description, (B) Location, (C) Dimensions, (D) Form, (E) Grade, and (F) Division of work.

Where the earth work is a part of other work, the location is usually sufficiently well described in the general description of the entire work; otherwise a special description may be desirable.

In minor works the description may include, in a single paragraph, all necessary facts in regard to location, dimension, form, grade, and divisions of work, while in important work each of these factors may require special treatment. The following examples show the common practice in the writing of such specifications:

§ 201. (A) Description, and (B) Location.

a. *For Channel or Ditch.*—"A channel having side slopes of two feet horizontal to one foot vertical, and a width of twelve feet at the bottom, shall be constructed on the grade shown on the profile from the outlet of Williams Pond to the Bear River on the general line shown on the map."

b. *Trenches for Pipe Sewers.*—"All sewers shall be located on the lines shown on the map. The trenches shall be excavated to a depth sufficient to place the flow line of the pipe on the grade shown on the profile, and of such a width that they shall be, at the center of the sewer, one foot wider than the greatest horizontal diameter of the pipe to be laid therein. The bottom of the trench shall be excavated as nearly as practicable to the form and size of the lower half of said pipe. Suitable excavations shall be made to fit all junctions or other specials wherever needed."

c. *Trench for Water Pipe.*—"1. Line and Grade: The trenches for the pipe shall be opened in accordance with the lines and grades given by the engineer. The pipe lines shall be laid uniformly twenty-two (22) feet from the northerly sides of the various streets and avenues. The right, however, to depart from this general rule is reserved by the first party."

"2. *Size of Trench:* Said trenches shall be one foot wider than the greatest exterior diameter of the pipe to be laid therein."

"3. *Bell Holes*: At all points the trench shall be widened and deepened sufficiently to admit of free access for calking all around said pipe, and so that the bell of the pipe shall have no bearing on the bottom of the trenches. Such enlargement of the trench shall be made before the pipe is lowered into it."

d. *Excavation for Bridge Substructures*: "The excavation for all piers or abutments shall be to such a depth as shall permit the bottom of the grillage, if grillage be used, or the bottom of the masonry footings, if no grillage be used, to be placed at an elevation about ninety (90) feet above city datum (to which reference plane all elevations on the drawings and in specifications for this work are referred). The engineer shall determine the exact elevation of the foundation of each structure. The excavation shall be of the size and dimensions directed by the engineer."

e. *Excavation for Masonry Foundations*: "The excavation will be of the form, dimensions and depth shown on the drawings, or to such additional depth as the nature of the material may require."

f. *Street Grading*: "All streets and avenues on which pavements are to be laid, including roadway, parking sidewalk intersection and all street and alley approaches shall be graded to the lines and cross sections shown on the profiles and sections of the same."

g. *Railroad Grading*: "Under this head shall be included all excavations and embankments for the construction of the roadbed for both main and side tracks, for all station grounds and switch yards, and including also the excavations for all drains and ditches in connection with the road, and the excavations for the foundations of all bridges, culverts, cattle guards, and all earth work necessary for the change and reconstruction of public or private roads and crossings, or for the changing of water-courses and for all other earthworks incident to the construction of said railroad."

h. *Chicago Drainage Canal*: "Location: "The work covered by and included in these specifications is the excavation of that part of the main drainage channel, and the building of certain collateral works for the sanitary district of Chicago located between the Willow Springs Road in Section 32 of Township 38 North, Range 12 East of the Third Principal Meridian, in Cook County, Illinois, and the middle of Section 14, near Lockport in Township 36 North, Range 10 East of the Third Principal Meridian, in Will County, Illinois, beginning below but near the said Willow Springs road, the said part of the said main drainage channel follows the Desplaines river valley, being located north and west of the Illinois and Michigan canal, approximately as shown on the accompanying plans, marked "2 a," and as shall be located by the engineer, and described as follows:

"The line of said channel shall begin at Willow Springs road and shall continue in a direction parallel to and 460 feet from the river bank of the canal above Willow Springs, joining by an easy curve a line parallel to and 460 feet from the canal bank in the straight reach above Sag, thence by an easy curve in a straight course to the county line and parallel to and 730 feet from the bank of the canal in the straight reach at and above Lemont; thence by an easy and continuous curve to a straight course parallel to and

460 feet from the canal bank in the straight reach at and below Romeo, said course terminating at or near the middle of Section 14, of Lockport Township; the course opposite Lemont to be subject to a change of 200 feet if found desirable, said course throughout being so located as to facilitate the spoiling of the waste material from the channel on either side. The total approximate length is 74,000 feet or 14 miles.'” (San. Dist. of Chicago.)

i. Embankment: “The embankments shall be 30 feet in width at the top, and shall have a slope of two (2) feet horizontal to one (1) vertical, or such other slope and such cross section as the engineer may determine for any particular case.”

j. Embankment: “In embankment, the sides shall be neatly and uniformly dressed to a slope of two and one-half (2 1-2) horizontal to one (1) vertical, or such other slope as the engineer may direct in any particular case.”

§ 202. (C) Dimensions, (D) Form, and (E) Grade.

a. Dimensions of Cross Sections: “The bottom of the finished channel shall have a width of 160 feet in the clear; where the channel is in rock, the sides of said channel shall be kept vertical, except as to necessary offsets occasioned by the use of channeling machine.

“The sides of the rock channel are to be worked out with a channeling machine from top to bottom, the channels being cut ahead of the blasting. In doing this the bottom of each cut of the machine is to be made to a uniform level above the grade, and each succeeding one offset six inches from the one just preceding. The contractor will be allowed to work the rock in one or more stopes, at his option, so far as concerns the main portion of the width of the channel, but in case he elects to work the face in stopes having a greater height than the reach of the channeling machine in depth, then the blast holes are to be so disposed as to effectually prevent any blast from breaking or shattering the rock beyond the sides of the prism of the channel, which are to be left as smooth and solid as can be obtained with a skillful and proper use of a channeling machine.

“In determining the width of the channel at the top of the rock, the necessary offsets made by the operation of the machine are to be allowed for. Provided, that where the depth of the rock does not exceed sixteen feet there shall be but one reach or cut of the channeling machine made, and that when its depth is over sixteen feet, and not greater than twenty-four feet, there shall be but two cuts made; and that nowhere is there to be more than three cuts made for the whole depth of the rock excavation.

“Where the channel is partly in earth and partly in rock, the earth shall be so excavated as to leave a berm on top of the rock equal to three-eighths (3-8) of the depth of the rock surface below a level 5 feet above datum; provided that the berm shall be in no event less than 5 feet; and provided, further, that where the section is entirely in earth the additional width at bottom shall conform to the above rule; and provided also, that at the level of 5 feet above datum the berm shall not be less than 10 feet, with a slope toward the channel of one-half foot. In all cases the earth shall be taken out with the least slope which is to be found can be safely maintained

until the retaining walls are built, and as may be directed by the engineer from time to time." (Spec. San. Dist. of Chicago.)

b. *Grade*: "The grade line of the bottom of said main channel at the station designated 740 shall be at an elevation of 24 feet below the datum established by the Illinois and Michigan canal trustees in 1847, and shall slope thence uniformly at the rate of 0.08 of a foot vertical to 1,000 feet horizontal to the end of the standard excavation at station 1480, where it shall have an elevation of 29.92 feet below datum.

"The sanitary district reserves the right to change said grade by raising or lowering it, or by increasing or decreasing the slope, thereby increasing or decreasing the amount of excavation; provided, that said change shall in nowise affect the terms of this contract as to price, or entitle the said contractor to any compensation additional to the rate fixed by this contract, or render the sanitary district liable for any damages, whatsoever, direct or indirect. Provided, further, that the said change shall in no place affect the grade by an amount exceeding four feet; and that the sanitary district shall notify the said contractor of any such change before any portion of said channel shall have been finished in conformity to the grade as hereinbefore specified." (Spec. San. Dist. of Chicago).

§ 203. (F) *Divisions*.—In contract work of large magnitude, it is frequently desirable for purposes of letting the work, to divide it into a larger or smaller number of divisions, reserving the right to let the contracts for such divisions to one or more contractors as the party letting the work may elect.

a. "Sections for the purpose of eventually designating different portions of the work and of dividing it into contracts, the said part of the main drainage channels shall be divided into 14 sections as follows:

"Section 1, extending from the station designated 740 to the station designated 800.

"Section 2, extending from the station designated 800 to the station designated 850.

"Section 3, extending from the section designated 850 to the station designated 900, etc., etc.

"Section 1, 2, 7, 8, 9 and 10 involves certain changes in the river channel opposite.

Section 9 involves a possible re-location of the Illinois and Michigan canal, and

Sections 8 to 14 inclusive may require railway changes.

The sanitary district reserves the right to make all river, canal and railway changes independent of the main work." (Spec. San. Dist. of Chicago.)

§ 204. *Materials*.—Specifications for materials should include a description of:

A. Their *general character* and the available information concerning the same.

B. Their *classification*, or the kinds of material to be moved, with exact definitions of the character of each class, for which a different price may or will be paid.

C. The *quality* of material, which may be used in different parts of the work or for different purposes (as for fills, back filling, etc.).

D. The *quantities*, including exact or approximate estimates of the amount of the material or of different materials to be moved.

E. The method of *measurements*, or the basis on which estimates will be made and the work paid for.

F. The *shrinkage* or *increase* in volume which will be involved in the handling of the material, to the extent that such change in volume influences the construction or cost of the work.

G. *Extra excavation*, or the material that will be paid for at an extra price either in excess of the common price or aside from a fixed sum that may be made for the major part of the work.

H. *Extra material* and *borrow pits*, or the sources apart from the location of the work at which material can or must be secured.

Much care is necessary in designating the meaning of words used in the description of materials, especially when any classification is allowed or when any expense is involved by their occurrence.

As pointed out in section 122, of chapter XI, the lowest proposals from intelligent contractors can be secured only by removing so far as practicable all doubts in regard to the nature of the work to be done and the consequent expense to be incurred.

Various earth and rock materials to be excavated resist the work of removal in a manner varying greatly with their character and physical condition. Materials like clear sand and mud offer little resistance, while other materials like rock, cement, gravel and indurated deposits of all kinds offer strong resistance.

§ 205. (A) **General Character.**—The nomenclature used to designate these materials has not been standardized and varies greatly with different engineers. Prelini¹ subdivides these deposits into “very loose soils,” “loose soils,” “friable soils,” “soft rock,” “ordinary rock,” and “hard rock.”

Gillette² classifies earth excavation into (1) “easy earth,” in which he includes loam, sand and ordinary gravel; (2) “average earth,” including sands and gravels impregnated with clay or loam where a pick

¹ See “Earth and Rock Excavations,” p. 42.

² See “Handbook of Cost Data,” second edition, p. 120.

or plow drawn by two horses is necessary for loosening before shoveling, and (3) "tough earth," in which he includes compact clays, the hard crusts of old roads and all earths so hard that one team of horses can pull and plow only with great difficulty but which two teams of horses can loosen with comparative ease. He adds, "this third class of earth passes by insensible degrees into what is called 'hard pan,' " which he defines as including very compact clay or a mixture of gravel or boulders with clay, and "sometimes soft shales that can be plowed with a rooter plow." Certain cemented gravels are sometimes called hardpan.

The earth and soils have also local names, for example "adobe," a term used in the southwestern portion of the United States to denote any clay of which sun dried brick or "adobes" can be made. "Gumbo" is used in the Mississippi valley to denote a black loam mixed with clay, exceedingly sticky when wet, and often very hard and tough when dry. "Marl" is technically a mixture of clay and lime, but is often employed to designate clay soils with only a small amount of lime, and sometimes disintegrating materials with a soapy texture. The term "quicksand" is usually applied to any sand or sandy material which flows readily when saturated with water.

Earthy materials are sometimes classified and described as follows:

1. "Loose earth" which may include those earths having little cohesion and offering little or no resistance to separation from the remainder of the deposit.

2. "Common earth," which may include those having some cohesion and may require the use of a spade for removal.

3. "Tough earth," which may require before removal the use of the pick to break it up. These include stiff clay, disintegrating rock and slightly cemented sands and gravel.

Rock materials may also be divided into three classes, on the basis of the resistance offered to removal, namely:

4. "Soft rock," which is easily removed by bars and wedges, such as loosely laminated slates and sand stones.

5. "Ordinary rock," which can be removed by bars and sledges, such as sand stones, etc.

6. "Hard rock," which must be blasted.

The soft and ordinary rocks may often be more profitably moved by the use of explosives.

Very often the term "loose rock" is used for rock which is uncemented and is loosened from its bed and can readily be moved. The

term is usually confined by definition to pieces of a limited size, often not exceeding three cubic feet in contents.

The term "bedrock" refers to rock in the natural bed, and it may possess various degrees of hardness.

Occasionally deposits are described by their geological names, although such description gives little information concerning their exact character, as the same geological deposits will vary widely in texture and condition at various places.

Examples:

a. *Excavation for Bridge Abutments:* "The material excavated will be earth, sand, gravel and fragmentary material of various kinds and shall be estimated by the actual cubic contents of the excavation as laid out by the engineer, and shall be paid for at the price per cubic yard bid for such excavation. The material shall be refilled around the completed abutments, and shall be replaced in layers and thoroughly tamped and any surplus material shall be removed by the contractor and wasted by him at such place or places as the engineer may direct, not more than five hundred feet from the excavator, the cost of all of which shall be included in the price bid for excavation."

b. *Borings and Soundings:* "The location of borings and soundings made along or near line of the aqueduct is shown on Sheet No. 1, which also shows what is regarded as the probable location of the surface of the ledge rock, but it is well known that the surface of the ledge may differ greatly from the location as shown, and that the character of the material encountered cannot be definitely determined by wash drill borings. There is, therefore, no expressed or implied agreement that the line of the surface of the ledge rock or the character of the material encountered by boring, as indicated upon the plan, is given approximately correct." (Met. Water & Sewerage Board.)

c. *Character of Material*—"General Character of Borings and Soundings: The character of the material through and in which the tunnel is to be constructed, is indicated on the profile, and sample of material taken from the borings made on the line of the work at the points shown on the drawings may be seen at the office of the City Engineer. These borings are believed to be practically correct, and to represent a fair sample of the material. It is expressly understood, however, that the city does not guarantee the accuracy of these borings, and should the conditions be found to differ from those indicated by said borings, the Contractor shall have, for this reason, no claim against said city."

d. *Wells*—"Nature of excavation: From the drillings of the first artesian well, it is believed that the strata which lie below the surface, and which may be encountered in sinking the shaft, will be approximately as follows:

"Drift (clay, sand, gravel), 67 feet in thickness.

"Coal measure shales, 5 feet in thickness.

"Burlington limestone, 96 feet in thickness.

"Kinderhook group, 261 feet in thickness.

"The general thickness and character of the strata as above given, are believed to be approximately correct. These conditions are, however, liable to variation, which variation and the resulting conditions shall be at the risk of the contractor, and said contractor shall not be entitled to any claims for extra compensation for any variation in said strata or in the conditions thereof from those above mentioned, or for any additional labor, material, or appliances which he is obliged to furnish by reason of such variation, or for any unforeseen difficulties encountered in the prosecution of this contract."

e. *Wells*—"Approximate description of strata: It is expected that the strata which will be encountered in sinking this well will be similar in its nature to the stratification of the first artesian well drilled at Monmouth, which stratification was, approximately, as follows:—

Drift	67 ft.
Coal measure, shale	5 ft.
Burlington limestone	96 ft.
Kinderhook group	261 ft.
Hamilton and corniferous	88 ft.
Guelph and Niagara	68 ft.
Cincinnati shales	83 ft.
Galena limestone	290 ft.
Trenton limestone	116 ft.
Saint Peter sandstone	156 ft.

Depth of first well..... 1,230 ft.

"Below the St. Peter sandstone there is an unknown thickness of the Lower Magnesian limestone, perhaps 300 to 500 feet in thickness, below which the potsdam sandstone deposits occur.

"The general thickness and character of the strata as above given are believed to be approximately correct. They are, however, liable to variation, which variation shall be at the risk of the contractor, and said contractor shall not be entitled to any claim for extra compensation for any variation in said strata from the above, or for any additional labor, material or appliances which he is obliged to furnish by reason of such variation, or from any unforeseen difficulty encountered in the prosecution of the contract."

§ 206. (B) **Classification.**—Classification is an attempt to subdivide earth and rock work into classes or kinds of material, which will from their nature require different methods of treatment, and consequently different expense in moving them. Where such differences exist it is usually desirable to ask for separate proposals for each class of material. Classification and the opportunity of securing a proper compensation for each kind of material which will or may be encountered, obviates the hazard of variation in the amounts of the different kinds of material and guarantees that the contractor will receive payments

on each kind in proportion to the amount that obtains. The difficulty that arises in carrying out classification lies in the difficulty of explicit definition of class and the difficulty of determining accurately whether a given material lies within one class or another. This determination has led to many disputes and much litigation. Many classifications for such material have been used. These sometimes include :

- a. Earth and rock.
- b. Earth, loose rock, and solid rock.
- c. Earth, hardpan, loose rock, and solid rock.
- d. Loose earth, common earth, tough earth, hardpan, loose rock and solid rock.

Frequently the materials embraced under such classifications grade almost imperceptibly one into another, and in adjusting the limits between earth and hardpan, hardpan and rock, considerable difficulties frequently arise.

As a rule the engineer should be empowered to decide under what class a material encountered shall be included and he will here find opportunity for the exercise of his best judgment.

Examples:

a. *Open trenches*—"Excavation: All excavation will be in sand, gravel earth, and other drift materials. No rock excavation is expected, but should rock be encountered in the trenches it shall be excavated six inches below the bottom grade of the pipe. All rock requiring blasting to remove will be paid for as rock excavation at \$2.00 per cubic yard, and said rock shall be measured eighteen inches wider than the outside diameter of the pipe at the hub end, and from the top of said rock to six inches below the bottom grade of the pipe. All boulders found in the trench requiring to be removed, measuring one-half cubic yard or more, will be paid for as rock excavation. In the excavation of rock, all blasts must be properly covered to guard against injury to surrounding objects, and the contractor will be held responsible for all damages to persons or property caused by carelessness or otherwise in the prosecution of this work."

b. "*Classification of Material*: All material such as earth, clay, sand, gravel, rotten or loose rock, which can be removed with pick and shovel, shall be classed as 'earth excavation.' All rock requiring blasting to remove, shall be classed as 'rock excavation.'"

In addition to the above classification, the class Hardpan is sometimes also used. When so used it is usually specified as follows :

"Hardpan shall consist of indurated clay, shales or cemented gravel, and which requires blasting for removal."

In addition to the above classifications, there are also often included in work, part of which is to be performed under water, the classifica-

tion as above indicated, modified by the additional provision "in water," "below water," and "dry" or "above water."

"All excavation below low water shall include all necessary extra work caused by the position, and shall be paid for at the price named in the accepted proposition."

c. *Open Trenches*.—"Two prices only are to be paid for materials excavated from the open trench and other excavations (except borrow pits), namely, one for the rock excavation, which is to cover all excavation of solid rock removed by blasting, and all boulders of one-third cubic yard or more in volume; and one for earth excavation, which is to cover the excavation of all other materials. The price to be paid for borrowed earth is to cover the excavation of all kinds of materials taken from borrow pits." (Met. Water & Sewerage Board.)

d. *Canals*—"Classification of Material.—All material excavated under the provisions of this contract is to be classified under one or the other of two heads, viz.: 'glacial drift' and 'solid rock.'

"Glacial drift shall comprise the top soil, earth, muck, sand, gravel, clay, hard-pan, boulders, fragmentary rock displaced from its original bed, and any other material that overlies the bed rock.

"Solid rock shall comprise all rock found in its original bed, even though it may be so loosened from the adjacent underlying rock that it can be removed without blasting." (Spec. San. Dist. of Chicago.)

e. *Grading*—"Classification: (a) All material handled under the head of 'Grading' shall be classified as follows: 'Solid rock,' 'loose rock,' and 'earth.'

"(b) Solid rock shall include all bed rock which cannot be removed without blasting, also all boulders or other masses of rock of not less than one cubic yard which require blasting before removal.

"(c) Loose rock shall include all soft shales or other soft or loose rocks which can be removed without blasting, even though blasting may be done to facilitate the work; also all boulders or other manner of rock of not more than one cubic yard, or less than ten cubic feet.

"(d) Earth shall include all soil, earth, sand, gravel, loose stone and boulders of less than ten cubic feet contents, and any other material of every description not clearly included under the specifications of solid rock or loose rocks; of all of which the engineer shall be judge."

(e) "All materials moved in grading shall be measured in excavation only, and estimated by the cubic yard under the following classes:

"Class 1. All material that can be plowed by an average eight-mule team, each animal weighing not less than twelve hundred (1,200) lbs., attached to a suitable ten-inch breaking plow, all well handled, by at least four men. Also, all loose material that can, without plowing, be loaded into a scraper by two men.

"Class 2. Indurated material of all kinds, which cannot be plowed as in Class 1, but which requires loosening by powder, and can then be removed by scraper.

"Class 3. All detached masses of rock, more than two and less than ten cubic feet in volume. And all slate or other rocks, soft or loose enough to be removed without blasting.

"Class 4. All rock, not included in the above classes which requires drilling and blasting."³

In discussing the above specification, the Engineering News remarks that in a similar specification a dispute arose in regard to the question of whether certain material should be classified as "hardpan" or "rock," and points out that while certain shales and hardpan may be loosened in small chunks by a plow, yet true economy of construction would require blasting. It seems desirable that the decision as to the classification of material should when practicable be based upon its economic working, which is generally a question of judgment and therefore a matter for honest difference in opinion. The News suggests that it would seem better to have samples of the various materials on file as the basis for the contractor's proposal. Even with this provision, the grading of material from one class into another may sometimes still lead to differences of opinion, misunderstandings and disputes.

§ 207. (C) Qualities of Material.

Examples:

a. *Embankments*.—"All material for the embankment shall be gravel, clay or earth, free from all organic matter, and be such as the engineer will approve. Any material used in said embankment and not so approved shall be removed by the contractor at his own cost and expense, and shall in no case be estimated or paid for."

b. *Refilling trenches*.—"Material for refilling.—The trenches shall be refilled with the excavated material provided it be of proper quality, but in case insufficient suitable material is thus obtained, that which is suitable shall be furnished by the contractor, without charge, and he shall remove from the ground or uniformly spread over the surface all material which is not used in filling."

c. *Refilling in rock excavation*.—"In refilling trenches from which rock has been excavated, the six inches below the pipe shall be refilled with sand, earth or loam, and carefully packed before the pipe is laid; and the trench around and for eighteen inches (18") above the pipe shall be filled with earth, properly tamped, above which the rock may be filled in, but no rock containing more than two hundred (200) cubic inches will be allowed to be used in the filling."

d. *Reservoir embankment*.—"No material shall be used which is not free from vegetable soil, roots or non-mineral matter. All stones more than

³ See Eng. News Sup., July 9, 1903.

one inch thick or more than three inches in maximum dimensions, shall be removed from the embankment before setting."

As noted in the Engineering News Supplement⁴ the last clause is an unusual and unnecessary requirement which will entail close inspection and extra expense. The usual limiting size for stones in reservoir embankments is four inches in diameter, and even such a limit seems entirely unnecessary in work of considerable magnitude, unless the material contains a superabundance of such material.

§ 208. (D) Quantities and (E) Measurements and Estimates.

Examples:

a. *Embankments: "Measurements.*—The measurement of all material used in the embankment shall be made in the embankment."

b. *Levees: Estimate of quantities.*—"The solid contents of the levee, computed to the established permanent grade and cross section only, will be paid for. Nothing will be allowed for shrinkage. The cost of clearing, grubbing and breaking the surface shall also be included in the price per cubic yard for embankment."

c. *Canals: "Measurement.*—Measurement for all excavated material will be made in excavation by the cubic yard of twenty-seven cubic feet, based upon the survey and cross-section notes of the engineer.

"All 'glacial drift' excavated under the direction of the engineer, whether in or out of the main channel, will be included in the measured quantities.

"'Solid rock' excavated within the limits of the dimensions and grade of the main channel, or of any river diversion channel, or for the placing of any bridge or other structure, as hereinbefore specified, or that shall be taken out by direction of the engineer, shall be included in the measured quantities, provided that nothing will be included for rock that comes out below grade in the excavation of any channel.

"The prices given herewith are to include all work herein specified as clearing and grubbing, levees for protection, pumping, roadways for working, back filling of retaining walls, and generally all work and material found necessary in prosecuting this contract." (Spec. San. Dist. of Chicago.)

d. *Tunnel excavation.*—"Excavation either in earth or rock shall be estimated of a diameter only as great as the outside of the specified walls of the shaft or tunnels. Any material resulting from caving, careless blasting, or any other cause by which material shall be removed from beyond the lines specified, shall be removed and refilled with suitable clay thoroughly rammed in place⁵ and at the contractor's expense."

§ 209. (F) *Shrinkage.*—Material when moved from its natural bed usually alters its volume, sometimes to a considerable extent.

⁴ Vol. 50, p. 224.

⁵ Concrete filling may be required and if so should be specified. The specification "good material as the engineer may require" is indefinite and unfair.

Earth when excavated and placed in an embankment usually shrinks, frequently as much as ten per cent of its original bulk. Rock on the other hand when broken and placed in a fill, increases its bulk on account of the voids between the pieces. This change in volume becomes important in considering earth and rock work. Earth work, if measured in embankment, will measure less than if measured in excavation, unless allowance is made for shrinkage. Embankments unless carried above the permanent grade will prove deficient unless extra material is furnished. Rock work will occupy a much greater space than in the bed from which it was taken.

Examples:

a. *Measurement.*—"When earth work, taken from borrow pits, is measured in embankments, an allowance of ten per cent. for shrinkage shall be made, and the net embankments will be estimated as ninety per cent. of the gross excavation."

b. *Provision for shrinkage.*—"One-tenth shall be allowed for the settlement or shrinkage of all embankments, regardless of the character of material used, or the method of construction, and no embankment that is not carried up one-tenth higher than the established grade shall be paid for. The allowance for shrinkage must be deposited on the crown and slope during the original construction in such a manner as to give the width of crown and the slope required, which slope shall be uniform from top to toe of fill."

§ 210. (G) **Extra Excavation.**—It is necessary to anticipate the possibility of a greater amount of excavation than that which would be estimated from the plans for an improvement on account of the frequent necessity of removing material which may be objectionable or to reach a more satisfactory foundation. In foundations for pavements, the following specification is often used:⁶

⁶ See Eng. News Sup., Vol. 50, p. 257.

"All clay and spongy material shall be removed to a depth to be determined by the engineer, not exceeding 12 inches below the bottom of the foundation, and shall be replaced with such material as the engineer may direct."

This specification is faulty for two reasons: (1) It does not describe the material with which the fill is to be made; (2) It does not provide for extra compensation when such filling is required.

If the spongy material is to be replaced by sand, gravel or cinders, it should be so specified. If the fill is to be of clay, the specification should be equally explicit; the source from which it is to be obtained should be specified, and a sample of the same should be provided so that there will be no uncertainties as to the character of the material which the engineer will accept.

While it may be desirable to avoid a bill for extras, it is seldom that extra expense is really avoided by requiring the contractor to assume risks for extra work for which he is to receive no compensation. A few test pits along the line of the work will give the necessary information as to the occurrence of unsuitable material for the foundation, and an allowance can be made in the original estimate for the cost of extra filling, and a bid for the same required when the work is let. In this way the contractor is relieved from hazard and can and will submit a lower proposal for the work.

Examples:

a. *General*: "All excavation deeper than shown on the drawings, and all extra excavations ordered by the engineer shall be estimated and paid for at the contract price."

b. *Grading for Pavements*: "All material more than eight inches below the established grade, together with all material excavated from above the grade of the finished pavement shall be classed as extra excavation and paid for at the price of such extra excavation named in the accepted proposal. The cost of all other excavation including all necessary excavation for curbing shall be included in the prices named for paving and curbing."

c. *Excavation for Trenches*: "Any increase in depth beyond that which is necessary to lay the pipes in the above described manner, if ordered by the engineer, shall be paid for at the price bid per cubic yard for extra earth excavated and backfilled; provided such extra depth average at least three inches the whole length of extra cut. A corresponding deduction will be made for all length of less depth than that specified, but no attention will be paid to an average less than three inches for the whole length of such trench. The contractor shall also make additional excavation whenever required for the purpose of securing a good and satisfactory foundation, for which work he shall be paid the price bid for extra excavation."

§ 211. (H) **Extra Material and Borrow Pits.**—Extra material that cannot be obtained from the location of the work is frequently needed for embankments and fills. In most work the land from which such material can be obtained is provided, but occasionally it may be desirable to depend on the contractor to secure such extra material from sources which he shall provide.

Examples:

a. *Contractor to Furnish Material.*—"The contractor shall make all necessary arrangements to secure the material for the embankment, and no material shall be taken from the public streets or highways except as removed in the necessary grading."

b. *Borrow Pits Provided.*—"All necessary land for borrow pits will be provided by the party of the first part."

§ 212. **Operations.**—Under this heading should be included all specifications in reference to the necessary operations by which earthworks are to be begun, prosecuted, and completed, including also all restrictions and necessary precautions which are to be taken in order to secure good work and protect public life and property and the work itself.

(A) to (E) Inclusive: Beginning Work, etc.

(A) *Dredge Work: "Beginning Work.*—The work shall be begun at the outlet, but the contractor may leave such temporary dams as may be necessary to hold back the water for the dredges, provided such dams are removed as soon as the progress of the work permits."

(B) *Grades and Lines.*—"The approximate depth of the excavation will be given by the engineer before the excavation is begun. Grade and line will be given by the engineer every 12½ feet at the bottom of the trench, on stakes to be set by the contractor."

(C) *Clearing and Grubbing: a. For Levees.*—"The ground to be occupied by the levee must first be cleared of all trees, stumps, logs, bush, weeds, and all perishable matter of every kind. All trees and stumps shall be grubbed out by the roots, and all work shall be done to the full satisfaction of the engineer."

b. For Reservoir.—"The entire surface of the ground on which the reservoir is to be constructed shall be cleared and grubbed of all trees, stumps, bushes and roots. All such material shall be removed from the reservoir area. All good timber shall be cut and corded, and shall be and remain the property of the city. All debris shall be burned or otherwise removed from the city property."

c. For Canal.—"The contractor will be required to remove all trees, stumps, buildings, fences, or other incumbrances within 150 feet of the center line of the channel, or that may be in the way of any collateral or subsidiary work herein specified. All such material of value shall be the property of the contractor, and all worthless material shall be disposed of as directed by the engineer. The cost of this work shall be included in the prices for excavation as hereinafter stated." (Spec. San. Dist. of Chicago.)

(D) *Breaking Surface for Levee.*—"The entire surface which will be used for the base of the levee shall be thoroughly broken with a spade or plow in order to form a satisfactory bond with the earth fill."

(E) *Changes in Roads and Railroads: "Railway changes.*—Throughout such sections of the work as may require a change in location of any railway, the contractor shall grade a double track road-bed with material from the excavations herein before specified, said road-bed to be thirty (30) feet wide on top, with side slopes of one and one-half to one, and conforming in height and location and in other particulars to the plans of the engineer, as shown on plan '2 a,' and the cost of any such work shall be included in the prices for excavation hereinafter stated. (Spec. San. Dist. of Chicago.)

§ 213. (F) Consolidation, Rolling, Tamping, etc.

a. *For Reservoir Embankment.*—"The embankment shall be built by dumping the material in uniform layers and to the full width thereof. The material so deposited shall be spread out in uniform layers not over twelve inches in thickness and thoroughly rolled with a road roller of approved weight and dimensions."

b. *For Levees.*—"The movement of all wagons, carts or scrapers used on the work shall be so directed that all parts of the embankment shall be made equally and uniformly compact."

c. *For Pavements.*—"The sub-grade, after being properly puddled and brought to the proper section, shall be thoroughly compacted by rolling and tamping in such manner and to such extent as the engineer may direct. The roller shall not be less than three (3) feet in diameter, or more than six (6) feet wide on the face, and shall weigh at least eight (8) tons, and it shall be so operated as to roll the entire sub-grade between the street curbs. All places that have not been or cannot be properly rolled, shall be tamped with square hand tampers of not more than twelve (12) inches square face, and not less than ninety (90) pounds weight. The rolling and tamping of the foundation shall always be kept at a distance of not less than one hundred (100) feet ahead of the pavement."

d. *For Pavements.*—"When the road-bed has been brought to sub-grade and before the curbs are set, and after the city has made any necessary improvements, the sub-grade shall be thoroughly rolled with a steam road roller, weighing not less than ten tons. Any soft and spongy places that may appear during the rolling, shall be filled with dry earth or old macadam and be rolled until they are firm and solid and conform to sub-grade, being sixteen (16) inches below the finished surface."

e. *Tamping Trenches.*—"In refilling the trenches, the earth fill in the bottom of the trench under, around, and six inches (6") over the top of the pipes and other castings, shall be carefully packed and well rammed with proper tools for the purpose. Care shall be taken to give the pipe a solid bearing throughout its entire length. The earth filling above the pipes shall also be sufficiently packed to prevent serious after settlement. The contractor will not be required to tamp the entire refilling, but the street shall immediately after refilling be put into a passable condition and kept so for the limit of guarantee; a crown being left over the trenches of not to exceed six inches (6") in the width of the trench, and solid enough to prevent a horse or wheel from sinking into it to a dangerous extent, of which the engineer shall be the judge. After rains, or at other times when any settlement occurs, either in the surface of the fill, or by the formation of holes beneath the crust, the trench shall be refilled and redressed, and all kept in a satisfactory and passable condition."

"The back filling shall be done as soon as possible after the sewer is completed at any point. The earth shall be placed carefully in layers of not over nine inches in thickness, and each layer, before the next is placed, shall be thoroughly wet or rammed as the engineer may direct, and the filling shall be packed and rammed under and around the sewer, with proper

tools, so as to effectually prevent all injury from settlement to the sewer, or of unusual repairs to the streets."

f. Consolidating Trenches: "(1) In refilling the trenches the earth on each side and six inches over the brick work shall be carefully laid in so as not to disturb the work, and solidly rammed. After this, the center may be struck, but no more load shall be placed on the arch until such time as the engineer may direct.

"(2) Special care must be taken in filling around the sewer to keep the earth the same height on both sides.

"(3) The first layer shall be placed in with shovels, and the sewers shall not be walked upon until this is done. The earth then to be thoroughly rammed in eight-inch layers, with in no case more than twice the number of men refilling than there are ramming.

"(4) The balance of the trench may be filled in the same manner, or by sluicing with water, as the engineer may direct."

§ 214. (G), (H) and (I) Limiting and Protecting Work.

(G) Limits of Work: "In no case shall the contractor be allowed to work any trench more than four hundred (400) feet in advance of the pipe laying unless otherwise permitted in writing by the engineer, and in all cases the refilling shall be kept within 200 feet of the completed pipe laying, unless otherwise given in writing."

(H) Bracing, Sheeting and Shoring: a. Shaft and Tunnel.—"The contractor shall furnish and place all necessary bracing and shoring for preventing caving in the shaft, or tunnels to be built under this contract. The contractor shall so protect his work from caving that it shall cause no settlement or injury to the walls of the pumping station or reservoir, or to the foundations of the same, or to the foundations of any machinery installed therein, and he shall make or cause to be made, or shall pay the cost of making any repairs to the city property damaged directly or indirectly by his operations."

b. Sheeting Excavation.—"In all cases when necessary to prevent the caving of banks, the contractor shall furnish and put in suitable bracing or sheeting at his own expense and remove the same when the trenches are refilled."

c. Removing Bracing, etc.—"Before the refilling, all shoring, bracing, etc., shall be removed from the trenches, but shall be removed only as the filling progresses in order to keep the trench from extensive caving."

(I) Protection, Care and Maintenance of Traffic: a. Bridging Trench.—"Should occasion require on any of the business streets, or in any street, the importance of which as a thoroughfare is great enough to make it necessary so to do, of which the city shall be judge, the contractor shall properly bridge the trench to permit a safe crossing of traffic."

§ 215. (J) Obstructions.—Improvements Encountered.

a. Obstructions.—"When necessary to cross or interfere with existing culverts, drains or pipes of any kind or description which may be so located in said streets, or any railroads, side tracks or other constructions, which

may be located in said street, notice shall be given to the city, and the work shall be done in accordance with the direction of said city or its representative. All objects requiring it shall be sustained in place until the work is completed and any damage caused shall be thoroughly repaired, and all work requiring strengthening to meet any additional strain caused by such excavation shall be properly made by the contractor to the full satisfaction of the city.

"All repairs of injury to pipes, drains or other obstacles encountered in or on the street, shall be properly made before filling over and around the same."

b. *Replacing improved surfaces.*—"In all cases the class of pavement before existing shall be carefully replaced so as to be in every way equal to the original surface in material and workmanship as far as practicable. In improved streets and through the business portion of the town, the contractor shall thoroughly tamp the material from the pipe to the surface so that no after-settlement shall occur."

c. "The contractor shall do whatever may be necessary to keep in position, and to protect from injury all water, gas pipes, service pipes, lamp posts, poles, and all other fixtures which may be encountered in carrying on the work. In case any of the said pipes, posts, poles, or other fixtures be damaged, they shall be repaired by the parties having control of the same, and the expense of such repairs shall be deducted from the amounts which may become due the contractor."

§ 216. (K), (L), (M) and (N) Pumping Methods, etc.

(K) *Pumping and draining: a. Trenches.*—"During the trenching and the laying of the pipe, the contractor shall properly dispose of all drainage or water seeking the trenches, by the employment of suitable flumes for conducting the water from the work, or by doing all necessary pumping and bailing. He shall provide for all waterways, ditches or sewers intercepted during the progress of the work, and replace them in as good and satisfactory condition as they were before they were disturbed, before the work will be accepted."

b. *Shaft and Tunnels.*—"During the construction and until the work is completed and accepted, the contractor shall promptly and properly dispose of all drainage water seeping into the shaft or tunnels by doing all necessary pumping and bailing, and he shall furnish all necessary machinery and apparatus therefor."

(L) *System of Excavation: a. Trenches.*—"All excavation shall be done by open cut from the surface. Trenches for pipe sewers, shall be eighteen inches wider than the diameter of the pipe. The bottom of all trenches, whether for pipe or brick sewers, must be as far as practicable excavated to the exact form and size of the lower half of the pipe, or sewer, to be laid therein. Suitable holes shall be cut for the pipe, bells, and for the proper fitting of all junctions when needed."

b. *Trenching.*—"The excavation will, in all cases, be continued from the surface to the bottom line of the same, unless otherwise specially permitted in writing by the city. The trench shall be properly and smoothly bottomed

so that the pipe will have a full length support. In excavating through improved street surfaces, the material shall be carefully removed and kept free from the other material excavated from the trenches.

"In order to facilitate traffic and interfere with the use of the public streets as little as possible, all trenches having an average depth of eight feet or more shall be excavated by the use of an overhead conveyor system with which the material excavated on one portion of the work shall be dumped directly into the trench in which the sewer is already completed.

(M) *Filling: Aqueduct Embankments.*—"The material is to be deposited and spread in horizontal layers not exceeding 3 inches in thickness, each layer to be sufficiently watered and very thoroughly rolled with a heavy grooved roller. From time to time during the construction of this portion of the embankments, and if so required, three times after its completion, this portion shall be so thoroughly saturated with water that it will stand upon the surface.

"The building of the aqueduct upon such foundation embankments shall not be begun until they have stood six weeks after completion, unless otherwise directed." (Met. Water & Sewerage Board.)

(N) *Drilling, Channelling, Blasting and Quarrying: a. Shaft and Tunnel.*—"If blasting is necessary in the removal of rock from said shaft or tunnels, due care shall be taken to protect all finished masonry or other work or material in said shaft or tunnels from injury due to the blasting. All blasting shall be carefully covered and all blasts shall be fired by means of electric igniter and detonating caps, and not by fuses."

b. *Canal.*—"The contractor is to furnish all explosive compounds for blasting the material provided to be excavated under this contract; and, whereas, the storing, handling, and use of so large an amount of explosive material requires the utmost care and discrimination, it is therefore understood and agreed that the said contractor shall arrange for the storage of all explosive materials at a distance not less than 600 feet from the work, or from any other magazine, or from any dwelling occupied as a habitation, and that not more than 5,000 pounds shall be kept in one place. It is further understood and agreed that said explosive material shall in no case be brought onto the work except when needed for the purpose of charging the blast holes, and then only in such quantity as is needed for the particular work in hand, and that none but skilled and careful men shall be employed in the handling or use of said explosive, and that no liquid explosive shall be used.

"It is further understood and agreed that the ground surrounding all magazines shall be kept free of vegetable or combustible material for a radius of one hundred feet, and that their walls shall be made bullet proof, to a height of one foot above the contained explosives, and that in no case shall they be made of brick or stone. It is also understood and agreed that such signals of danger, as may be directed by the engineer, shall be given or displayed before the firing of any blast, and that the said contractor shall conform his acts to and obey all rules and regulations relative to the handling of explosives and the firing of blasts, for the protection of life or prop-

erty, which may be made by the engineer from time to time." (Spec. San. Dist. of Chicago.)

§ 217. (O) Disposal of Material and (P) Overhaul.

(O) *Disposal of Material: a. Shaft and Tunnel.*—"The material from the shaft or tunnels shall be deposited at the point directed by the engineer, the distance to which shall not exceed three hundred feet from the top of the shaft."

b. *Street Work.*—"All excavated material shall be disposed of as follows: First, it shall be used to make any fills necessary to bring the foundation of the street to the proper grade; second, it shall be deposited on any street or alley or lot or parcel of land within one thousand feet of the place of excavation, which may be selected or designated by the engineer, and third, the balance of said material shall be removed from said street by the contractor and at his own expense, and may be sold or otherwise disposed of as he may elect.

"The city reserves the right to all cobble stones, gutter crossings and cross walk stone in good condition, after the same have been taken up by the contractor, who shall use due care in handling the same so as not to break them, and shall carefully pile the same at such points on intersecting streets as the engineer may direct."

c. *Trenches.*—"The material from the trenches shall be so deposited as to interfere as little as possible with public travel or the convenience of the residents on the thoroughfare in which the excavation is made."

d. *Trenches.*—(a) The excavated material or other material used on the work shall be laid compactly on the sides of the trench, and kept piled or trimmed up so as to be of as little inconvenience as possible to the traveling public and adjoining tenants.

(b) Said material shall not obstruct the gutter of any street, and all proper measures shall be taken to provide for the free passage of surface water along the gutters.

(e) *Canal.*—The contractor, except as hereinbefore specified, is to dispose of all material to be excavated under the terms of this contract at his own expense, and in the most convenient manner, in waste banks on the right of way; provided, that the foot of the inner slope of said banks shall not be nearer to the edge of the main channel than 50 feet, measured at an elevation of 10 feet above datum, and that the foot of the outer slope shall not approach the margin of the right of way closer than 10 feet, nor encroach on the channel of the Desplaines river as finally established, and so as to materially interfere with the flow thereof; the slopes next the channel and said margin of river to be not less than one and one-half to one, and said waste banks to be within the limits of 450 feet from the edge of the main channel, and provided that this shall not be construed to prevent any other disposition of the material with the consent of the engineer." (Spec. San. Dist. of Chicago.)

(P) *Overhaul.*—"All material shall be delivered at such points, within fifteen hundred feet of the work, as the engineer may direct. On any ma-

terial delivered at a greater distance, 'overhaul' will be allowed for each one hundred feet in accordance with the prices named in the accepted and attached proposal.

§ 218. (Q), (R), (S) and (T) Completion and Maintenance.

(Q) *Grading, Leveling and Dressing.* (a) "The slopes of the embankment shall be carefully and evenly dressed to the lines given; all to the satisfaction of the engineer."

b. "The slopes shall be carefully brought to the proper sub-grade and dressed with four inches of loam of approved quality."

(R) *Sodding and Seeding.* (a) *Sodding.*—"After the slopes are dressed to grade they shall be sodded with fresh cut sod carefully pinned in place, which shall be kept well watered for 30 days thereafter."

b. *Seeding.*—"After the slopes are covered with a loam dressing, as elsewhere specified, they shall be carefully seeded with blue grass, and also sown with oats to protect the young grass. The seeding shall be carefully watered for 30 days thereafter."

(S) *Continuous Prosecution of Work.*—"Should treacherous material be encountered such as quicksand, running sand, etc., and the conditions of the work, in the opinion of the engineer so demand, the work shall be pushed with the utmost vigor and shall be carried on continuously night and day."

(T) *Maintenance.* a. "All embankments are to be maintained for one year after completion, and any erosions shall be carefully filled and compacted, and the work shall be left in condition satisfactory to the engineer at the end of the year period."

§ 219. **Assignments on Specifications for Earth and Rock Work.**—The student should select one or more of the following subjects and

First: Outline the various subject headings which should be included in a specification for the required work; and

Second: Prepare or select proper specifications which will assure a correct understanding of the nature of and the manner in which the required work is to be done.

NOTE.—In each case it will be desirable to give the subjects a local significance by applying the work to local conditions that can be investigated, and by giving definite dimensions to the work.

Excavation and Grading:

Excavation for the basement and foundations of a building.

Grading around a public building.

Grading an athletic field.

Grading a city block for building purposes.

Regrading a hilly portion of a city (hydraulic process).

Grading a street through a considerable rise.

Excavation for pavement and preparation of subgrade.

Stripping and Grubbing:

Stripping surface for reservoir.

Stripping surface for quarry or open mine.

Fills and Embankments:

Filling across a ravine for highway purposes.

Construction of levee by scrapers.

Construction of levee by machinery.

Construction of a railway fill by scrapers.

Construction of a railway fill by steam shovels and cars.

Excavation for culvert under railway in operation.

Construction of earthen reservoir dam by scrapers.

Construction of earthen reservoir dam by cars.

Construction of earthen reservoir dam by machine work.

Construction of earthen reservoir dam by hydraulicing.

Ditching and Dredging:

Construction of an irrigation canal, hand finished for lining.

Construction of drainage (or irrigation) ditch by hand work.

Construction of drainage (or irrigation) ditch by scrapers.

Construction of drainage (or irrigation) ditch by machinery.

Dredging a river bed for boat channel.

Dredging a river or lake for a dock.

Excavation within cofferdam for dam foundations.

Excavation within cofferdam for pier foundation.

Shaft and Tunnels:

Construction of tunnel in earth for railway.

Construction of tunnel in earth for aqueduct.

Excavating a dug well.

Excavating a mine shaft.

Trenching:

Construction of trench for pipe sewer.

Construction of trench for brick sewer.

Construction of trench for concrete sewer.

Construction of trench for water pipe.

Construction of trench for electric conduits.

Construction of trench for electric cable.

Miscellaneous:

Excavation for transmission tower base in hard ground.

§ 220. Assignments of other Fundamental Processes.*Bank Protection:*

Furnishing and placing heavy riprap.

Furnishing and placing riprap paving.

Furnishing and placing block stone paving.

Furnishing and placing rock filled timber cribs.

Brick Masonry:

Laying common brick in walls of building.

Laying fire brick and common brick in boiler setting.

Laying face brick in building fronts or enameled brick in engine room wall.

Laying hard brick in boiler room floor or sidewalk.

Laying brick in sewers, chimneys or pavements.

Laying common brick in bus bar compartments.

Brush Mattress:

Making and placing, including covering with riprap and sinking.

Carpenter Work:

Constructing concrete forms (finished work or rough work).

Framing timbers for crib dams or trestle work.

Framing timbers for headings and tunnels or shafts.

Coffer Dam:

Clay embankment (for shallow water).

Sand and clay embankment with sheet piling inner wall.

Two rows of sheet piling filled with puddle.

Rock-filled crib with outer sheeting of wood.

Rock-filled crib with outer sheeting of steel.

Concrete Work—Plain or Reinforced:

Making concrete (mixture⁷) and placing foundation of roads or machinery.

For retaining wall or piers and abutments.

For sidewalk, floors or curb and gutters.

For arched bridge or culverts.

For ditch or tunnel lining.

Concrete Work—Reinforced:

For fence posts, bearing piles or transmission poles.

For reservoirs—walls and bottom or lining.

For beams, slabs or columns.

For sewer pipe or culverts.

Fencing:

Railroad right of way or highways.

Farm property for horses, cattle or poultry.

⁷ Mixture to be selected or assigned.

Highway and Street Construction:

Foundations of gravel, cinders, concrete, broken stone or Telford.
Surface of gravel or crushed granite.

Macadam (water bound, oil bound or with bituminous wearing surface).

Cedar block, Douglas fir block or creosoted wood block.

Vitrified brick or stone blocks, sheet or block asphalt.

Machinery and Appurtenances:

Furnishing steel castings for gears.

Furnishing steel forging for connecting rods or shafting.

Furnishing iron castings for engine cylinders and machine frames.

Furnishing castings for large gears (uncut or cut gears).

Furnishing brass castings for bearing boxes.

Machine Shop Work:

Boring engine cylinder.

Forming and finishing piston rod and connecting rod.

Making and furnishing bolts and nuts (ordinary or finished work).

Riveted work for large penstock or turbine housing.

Riveted work for ordinary return tubular boiler.

Riveted work for best Scotch marine boiler.

Riveted work for house tank or standpipe.

Painting:

Steel bridge or steel poles and towers.

Frame building (exterior) or windows and door frames of brick power house.

Steel standpipe or steel penstock.

Interior steel trusses of power house or plaster walls of engine room.

Finishing hard pine floor or wainscoting of engine room.

Piling:

Driving bearing piles for foundation of power station or brick chimney.

Driving sheet piling in a dam foundation of wood or of steel.

Driving concrete bearing piles or casting concrete bearing piles in place.

Sawing off round piles under water or cutting off steel piles in place.

Pipe:

Furnishing and laying lead joints or flange joints.

Furnishing and laying concrete sewer pipe or reinforced concrete conduit.

Furnishing and laying vitrified sewer pipe.

Furnishing and laying riveted steel pipe.

Piping for connecting steam engine and boiler of steam engine and condenser.

Covering exposed water pipe over bridge or to elevated tank.

Plastering, etc.:

Placing wood lath or metal lath.

Placing back plastering, scratch coat, brown coat or finishing coat.

Rock Work:

Quarrying stone for building, rubble, concrete or riprap.

Excavating rock for railway cut (in dry) or navigation canal.

Excavating rock for shaft or tunnel.

Roofing:

Laying shingles of wood, asbestos or slate.

Laying roof of slate, tile, tar and gravel, composition or metal.

Stone Masonry:

To cover size, laying, bond, joints, etc.

To cover bridge pier masonry of coursed ashlar.

To cover building pier of uncoursed rubble.

To cover dam of broken ashlar.

To cover retaining wall of coursed rubble.

To cover wall of building, random range ashlar.

To cover buildings, dressed faced coursed ashlar.

Transmission Line:

Framing and erecting timber poles.

Stringing conductors and galvanized steel ground wire.

Setting concrete bases or distributing tower material.

Assembling and erecting towers and hanging insulators.

CHAPTER XIX

SPECIFICATIONS FOR MACHINERY AND APPARATUS

§ 221. **Divisions.**—Specifications for machinery and apparatus may be divided into three classes.

First. General specifications are usually prepared for occasions when it is proposed to purchase standard designs of manufactured machinery. Such specifications should definitely designate:

- A. The kind and number of machines to be furnished.
- B. The purpose for which they are to be used.
- C. The capacity.
- D. The condition of operation.
- E. The conditions of delivery, foundations and erection.
- F. The tools and appurtenances required.
- G. The time of delivery.

H. The specification may also include such other special requirements in regard to type of machine desired as will confine the bidders to the machine more nearly fitted for the requirements of the conditions.

I. The requirement of full specifications from the bidder as to the particular characteristics of the machine he proposes to furnish.

Second. Detailed specifications are usually prepared for occasions when it is proposed to purchase machines which are designed by the manufacturer but which are manufactured to order and are more or less special, in accordance with the demands of the purchaser.

Such specifications not only accurately define the requirements outlined under "General Specifications" but also describe at considerable length the requirements for material, workmanship, finish and strength of all or the principal parts of the machine to be furnished.

Third. Design specifications are usually accompanied by complete detailed plans, and designate definitely and minutely in full detail every part and portion of the machine to be provided, describing the material from which it is to be made, its qualities and strength, the workmanship and finish, and the weight, size and dimensions of all parts.

The above divisions are more or less arbitrary and in practice such specifications often grade imperceptibly from one to the other.

§ 222. **General Specifications.**—In general specifications for machinery and appurtenances, all essential requirements of the machine needed, and the work to be done by it, should be specified. These should be given in sufficient detail so that manufacturers may understand what class of machinery is desired or what class is best adapted to the work. In such specifications, all general requirements that are fixed by the conditions should, so far as possible, be specified. If the machine must be horizontal or vertical, if its size must be limited, or if there are any other requirements which are definite and can be fixed, they should be stated. The conditions of installation and the other requirements for a pump will usually determine whether it should be a steam pump or a power pump, and if the latter, whether it should be reciprocating or centrifugal. If a power pump is required, the prime mover to be used is usually known, and whether it will be operated by rope drive, belt or by direct connection.

The requirements for a steam engine will usually determine whether it should be simple or compound, condensing or non-condensing, and probably define certain other features which should be specified.

Unless the specifications limit the most common details, the bids under them will often embrace an exceedingly great variety of machinery which will differ widely in the manner in which it will fulfill the requirements. Such a multitude of proposals for a great variety of machines, differing widely in character, will be difficult of comparison even when the engineer is thoroughly familiar with the type of machinery in question and with the effect of changes in design on the economy of operation, and will leave the novice or those unfamiliar with the machinery greatly perplexed.

General specifications, where few or no details are included, are best adapted to occasions on which the competition can be limited to manufacturers known to be responsible and experienced, and whose line of goods can be taken largely on its merit with little or no question in regard to the character of material or of details.

Where, as in the case of public lettings, the competition must be opened to all, and the award must be made to the lowest responsible bidder, such specifications do not offer a sufficient protection to the purchaser, and greater detail is essential. For such lettings, it is necessary to protect the purchaser from unscrupulous bidders, and the specifications must be drawn so complete as to prevent the use of improper material and construction.

Limiting Details.—It is usually undesirable, except in special cases, to limit in great detail the dimensions of the parts of standard machinery. The standard machines of all first class manufacturers possess characteristics peculiar to that maker, characteristics on which much of the success of the machinery often depends, and on which the reputation of the manufacturer has been established. Specifications requiring changes in such designs should seldom be written, and then only when the peculiar local conditions absolutely require such changes. If the type of machinery made by such a manufacturer comes within the requirements of the case in hand, the specifications should be drawn so broadly as to admit the use of the valuable features of all first class makers. For example, in pump and engine specifications, it is usually undesirable and unfair to specify certain exact cylinder sizes and dimensions for, as a rule, no advantage will result, and the manufacturers whose standards are different are greatly and unjustly handicapped thereby. Similar unnecessary requirements concerning the exact dimensions of other portions of an engine or of other machines should be avoided.

§ 223. **Selections.**—Where specifications are general and not specific, the standing and experience of the maker become important and an investigation of his general reputation, the length of his experience, the facilities he possesses for manufacturing, and the design and workmanship of the machinery ordinarily made by him, is desirable. Frequently, extensive manufacturers of a certain class of machinery make a specialty of a certain type or capacity, and in such cases may not have the experience necessary for the successful manufacture of machinery of a different type or capacity. A machine furnished and manufactured by such parties often possesses the general characters of experimental work, and is likely to be only partially successful. Letters and references are of little value in this connection, unless carefully investigated and found to be from responsible disinterested parties, and based on a class of machinery similar or identical with the class needed for the particular purposes at hand.

§ 224. **Detailed Specifications.**—The preparation of detailed specifications departs from the general specifications only in the elaboration of the specification of details.

Detailed specifications for standard machinery can generally be drawn in such a manner as to avoid the necessity of requiring special machines. The general details adopted by first-class manufacturers can be specified, and, where practice differs, specifications may be so

drawn as to admit the alternative of two or more first-class methods of manufacture. Such a method manifestly demands an intimate knowledge of correct practice, but such a knowledge is always necessary for correct specification writing.

Considerable experience with the particular kind of machinery or apparatus in question is necessary before the engineer should venture to issue specifications in great detail. The builders of first-class machinery, who are usually men of extensive experience, are slow to take contracts to manufacture machinery which is more or less special, and which may depart radically from the types or details they have found most desirable in their own line. Usually such specifications should be confined to requirements for workmanship and material, ample dimension and strength, and other requirements which will assure first-class construction and economy of operation without modifying seriously the fundamental design of the manufacturer.

§ 225. **Design Specifications.**—When plans for a machine of new design are prepared, full and detailed specifications, describing the character of material and workmanship of each part, are essential and should accompany the working drawings. Such specifications admit of great elaboration, but even in such cases the design and specifications should be kept within standard commercial lines with regard to sizes of rods, bolts, etc., wherever possible. Such specifications require an intimate knowledge of the principles and practice of design and manufacture, and should be attempted only by the practicing engineer of experience.

Contracts for special machinery of any kind can, of course, usually be placed, if such machinery is essential to the particular installation in view. Competition for such work however is limited, and the expense of departing from regular designs is often so considerable as to make the price of special machinery considerably greater than that of regular types. This is essentially true of machines that can be classed as "standard," which are in general use and are manufactured in large quantities. In other classes of machinery and apparatus which are simple in design and more or less special, it is sometimes found that a considerable saving can be made over prices demanded by manufacturers for the adaptation of their special designs, by the preparation of detailed plans and specifications for the manufacture of a particular machine for a special purpose on carefully selected and economical lines.

§ 226. **Preparation of Specifications for Machinery.**—In general, whenever a specifications is prepared for any particular machine, it must contain certain information which will be necessary as a basis for any intelligent proposal for the same. Every specification must be complete to this extent, even though it be in the simplest possible form, such as a letter of inquiry for prices on the machine desired.

From such a simple form, the specifications may be elaborated to the extent that the engineer finds it desirable to be more explicit as to his requirements for certain specific features, and even to the extent of including full detailed specifications (together with full detailed plans) for the size, dimensions, material and workmanship for each and every part of the entire machine.

In considering the simplest requirements for machinery specifications on which an intelligent bid may be made, certain data are found to be absolutely essential and certain other data are desirable. These may be classified as:

- A. Specifications which must always be included; and
- B. Specifications which should be included when practicable.

In the preparation of specifications for machinery or apparatus, it is essential, especially for the young or inexperienced engineer, to prepare an outline for the general requirements which should be embodied in the specifications for the machine or apparatus under consideration. The manner in which this may be done is shown in the following outlines which have been used for some years by the author in his own professional practice.

§ 227. **General Requirements for Specifications for Steam Boilers.**

A. Specifications for steam boilers must always include:)

- (a) Number of boilers required.
- (b) Steam pressure which the boilers will be called upon to furnish.
- (c) Boiler capacity required—
 - Boiler horse power.
 - Number of pounds of dry steam at specified pressure horse power and description of machinery for which steam is to be furnished.
- (d) Purpose for which boilers are desired.
- (e) Boilers to be delivered where.
- (f) Foundations and settings to be furnished by whom.
- (g) Boilers to be erected by whom.
- (h) Specify tools, fittings and equipment to be furnished with boiler, which may include some or all of the following:
 - Complete boiler settings.
 - Grates, plain or rocking.

Smoke stacks and guys.
Furnace tools.
Safety valve.
Steam gauge, with siphon.
Water gauge with stand-pipe.
Gauge cocks.
Blow off valve.
Check valve.
Stop valve.
Whistle steam piping and covering.

(i) Time of delivery.

(j) The bidder should be required to specify:

Diameter of boiler.
Length of boiler.
Number, diameter and length of flues or water tubes.
Weight of boiler.
Weight of fixtures.
Thickness of shell.
Thickness of head.

(k) Bidder should be required to furnish setting diagram showing floor space occupied, and position of all pipes and connections, or catalogue cuts or prints showing the type of boiler offered.

(l) It is desirable to require the bidder to submit detailed specifications describing the general and particular features in the construction of the boiler on which the proposition is submitted.

(m) Avoid so far as possible specifying exact dimensions of features mentioned under "j," for all detailed specifications requiring departures from the maker's standard, mean extra and often unnecessary expense.

B. Boiler specifications should also include:

(a) Position—vertical or horizontal.

(b) Type:

Plain cylinder.
Return tubular.
Locomotive.
Scotch marine, or
Other internally fired boiler.
Water tube.

(c) Economy:

Efficiency or economy required.
Tests to be exacted.

(d) Guarantee, insurance and forfeiture:

Guarantee and insurance for one year against accident due to poor workmanship or material.

Forfeiture for delay and premium for early completion.

(e) Payments.

§ 228. General Requirements for Specifications for Steam Engines.

A. Specifications for steam engines must always include:

- (a) Number of engines required.
- (b) Steam pressure under which the engines will be operated.
- (c) Horse power required.
- (d) Engines to be used for

{	Direct-connection to drive	}	What machinery?
	Belt-connection to drive		
	Rope transmission to drive		
- (e) Engines to be delivered where.
- (f) Foundations to be built by whom.
- (g) Engines to be erected by whom.
- (h) Specify tools, fittings and equipment to be furnished with engine, which may include some or all of the following:
 - Sub-base.
 - Indicator connections.
 - Steam separator and trap.
 - Driving pulley, clutch couplings, or other connections.
 - Governor size—if throttling.
 - Steam pipes and covering.
 - Drain or drip pipes.
 - Throttle valve.
 - Oiling devices.
 - Foundation bolts.
 - Tools and wrenches.
- (i) Time of delivery.
- (j) The bidder should be required to state the dimensions of the following parts of the machine on which he bids:
 - Diameter of cylinder or cylinders.
 - Length of stroke.
 - Diameter and length of main bearings.
 - Diameter and length of crank pin.
 - Diameter and length of cross head pin.
 - Dimensions cross head bearing surface.
 - Diameter of fly-wheel.
 - Weight of engine.
- (k) Bidder should be required to furnish setting diagram showing floor space and position of pipes, catalogue cuts or prints showing general type of machine offered.
- (l) In general it is desirable to require bidders to submit detailed specifications describing the general and particular features in the construction of the machine on which a proposition is submitted.
- (m) Avoid as far as possible specifying exact dimensions of cylinders, or other features mentioned under "j," for all detailed specifications requiring departures from the maker's standards mean extra and often unnecessary expense.

B. These specifications should also include:

- (a) Position—vertical or horizontal.
- (b) Expansion—simple or compound; cut-off; cylinder ratio; number of expansions or release pressure.
- (c) Condensing or non-condensing.
- (d) Type:
 - Slide valve.
 - Automatic.
 - Corliss, etc.
- (e) Speed:
 - Piston speed.
 - Number of revolutions, or
 - Speed of periphery of band wheel.
 - Where the engine is to be purchased to drive a particular machine, either by belt rope or direct connection, the speeds of both driver and driven must be so mutually arranged as to obtain the required results.
- (f) Arrangement of crank:
 - Center crank.
 - Side crank.
- (g) Regulation and economy:
 - Regulation or limiting variation of speed under variations in loading.
 - Efficiency or economy required.
 - Test to be exacted.
- (h) Finish:
 - Lagging.
 - Painting.
 - Polishing.
- (i) Guarantee and forfeiture:
 - Guarantee for one year against breakage due to poor work or material.
 - Forfeiture for delay, and premium for early completion.
- (j) Payments.

§ 229. General Requirements for Specifications for Pumps.

A. Specifications for pumps must always include:

- (a) Number of pumps required, and whether steam or power pumps.
- (b) Steam pressure under which the pumps will be operated.
 - Water pressure which the pumps will be required to furnish.
- (c) Capacity of pumps required in gallons per minute, or million gallons per day.
- (d) Service on which pumps are to be placed.
 - Fire service.
 - Elevator service.
 - Direct pressure water works system.
 - Pumping into a stand-pipe.

Pumping into a reservoir.

- (e) Pumps to be delivered where.
- (f) Foundations to be built by whom.
- (g) Pumps to be erected by whom.
- (h) Specify tools, fittings and equipment to be furnished with pumps,
which may include some or all of the following:
 - Indicator connections for both steam and water end.
 - Steam pipe connections and covering.
 - Steam separator and trap.
 - Size of driving pulley.
 - Drain or drip pipes and air cocks.
 - Throttle valve.
 - Oiling devices.
 - Foundation bolts.
 - Tools and wrenches.

- (i) Time of delivery.
- (j) Bidder should be required to specify diameter of cylinder or cylinders.
 - Length of stroke.
 - Weight of pump, together with such other information as the particular type of pump purchased will make desirable.
- (k) Bidder should be required to furnish setting diagram showing floor space and position of pipes and connections, catalogue, cuts or prints showing general type of machinery offered.
- (l) In general, it is also desirable to require bidders to submit detailed specifications describing the general and particular features in the construction of the machine on which the proposition is submitted.

B. These specifications should also include:

- (a) Position—vertical or horizontal.
- (b) Expansion—simple or compound.
 - Cylinder ratio.
 - Number of expansions, or release pressure.
- (c) Condensing or non-condensing.
- (d) Type:
 - Single cylinder double acting.
 - Duplex cylinder double acting.
 - Crank and fly-wheel high duty.
- (e) Speed:
 - Piston speed.
 - Number of strokes or revolutions.
- (f) Economy:
 - Duty.
 - Efficiency or economy required.
 - Test to be exacted.
- (g) Finish.
 - Lagging.

Painting.

Polishing.

(h) Guarantees and forfeitures.

Guarantee for one year against breakage due to poor work or material.

Forfeiture for delay, and premium for early completion.

(i) Payments.

§ 230. General Requirements for Specifications for Electric Generator or Motor.

A. Specifications for electric generators or motors must always include:

(a) Number of machines required.

(b) Class of machinery:

Direct current, voltage, winding (shunt, compound or series).

Alternating current:

Voltage, regulation, frequency, phase and power factor under which machine will operate.

(c) Capacity required in kilowatts or H. P. overload requirements.

(d) Generator or motor to be used:

Direct connected.

Belt connected, or

Rope connected to what machine.

(e) Machines to be delivered where.

(f) Foundations to be built by whom.

(g) Machines to be erected by whom.

(h) Specify tools, fittings and equipment to be furnished with machines, which may include some or all of the following:

Switch-board and connections, including voltmeter, ammeter, wattmeter, lightning arresters, switches, lights.

Portable measuring apparatus, including voltmeters.

Ammeters.

(i) Time of delivery.

(j) The bidder should be required to specify type of machine on which proposition is made.

Number of revolutions.

Diameter and length of main bearings.

Type of bearing.

Efficiency at full, three-quarters and half load.

Size of pulley (if used).

Class of belt, or other connecting mechanism to be furnished.

Guaranteed limit to heating under load.

(k) Bidder should be required to furnish setting diagram showing the floor space and position of connections, catalogue cuts or prints showing general type of machine offered.

(l) In general, it is desirable to require bidders to submit detailed specifications describing the general and particular features

in the construction of the machine on which the proposition is submitted.

- (m) Avoid as far as possible specifying exact dimensions or other features mentioned in "j," for all detailed specifications requiring departures from the maker's standard mean extra and often unnecessary expense.

B. Specifications for this type of machinery should also include:

- (a) Greater detail concerning type of machine desired.

- (b) Speed:

Necessary specifications controlling speed, modified by the purpose for which machine is to be used.

- (c) Regulation and economy:

Regulation limiting variations of speed under variation in load.

Efficiency or economy required under variations in load.

Test to be exacted.

- (d) Finish.

- (e) Guarantee and forfeiture:

Guarantee for one year against injury due to poor work or material.

Forfeiture for delay and premium for early completion.

- (f) Payments.

§ 231. **Assignments for Preparing Outline of General Requirements for Machinery and Apparatus.**—The preceding examples simply outline in logical order the general requirements for those features which should or may be included in the specifications for certain machines or apparatus.

The student should select one or more of the following subjects, and should

First: Furnish an outline of the requirements which should or may be included in the general specifications.

Second: On the basis of the outline prepared he should write a letter to some leading manufacturer, including therein all data necessary to secure an intelligent proposition for the assigned machine or apparatus.

Third: He should make a more complete outline for a general or detailed specification, arranging in logical order the various features and subdivisions which should be included in the specification for the subject assigned similar to the examples given in secs. 232 to 238 inclusive.

Fourth: He should prepare a general or detailed specification for the selected subject, in general accordance with the examples given in secs. 239 to 242 inclusive.

§ 232. **Subjects for Outlines and Specifications.**

Acetylene Blowpipe for Welding.

Air Compressor.

Air Pump for Condenser.
 Ammonia Compressor for Refrigeration.
 Ash Handling Machinery.
 Boiler—Fire Box, Scotch Marine, Water Tube, Steam Heating or Hot Water Heating.
 Condenser, Surface or Jet.
 Conveyor, Belt, Bucket, Cableway, Screw or Helicoid.
 Cooling Tower.
 Crane, Traveling or Gantry.
 Derrick, Stiff Leg or Guyed.
 Dredge, Steam—Bucket.
 Drill, Rock—Steam Driven or Air Driven.
 Drill, Twist—Drill Press.
 Economizer.
 Engine, Internal Combustion—Gasoline, Kerosene or Producer Gas.
 Engine, Steam—Corliss, Cross Compound or Hoisting.
 Electrical—Batteries, (Storage), Fuses, Heaters, Insulators, Lamps (Arc), Lightning Arresters, Meters, Motor-generators, Oil Drying Outfit, Rectifiers, Relays, Regulators (Constant Current, Feeder or Voltage), Rheostats, Switchboards, Switches (Air Break or Oil), Transformer (Constant Potential or Constant Current).
 Elevator, Hydraulic—Plunger or Accumulator.
 Elevator, Electric.
 Forging Press.
 Furnace—Automatic Stoking, Foundry Cupola or Hot Air Heating.
 Feed Water Heaters.
 Fan—Mine-blowers, Dryers or Forced Draft.
 Gas Producer.
 Hoist—Mine Hoist, Tainter Gate Hoist.
 Hydrant for Fire Protection.
 Pile Driver—Drop Hammer or Steam Hammer.
 Pump—Boiler Feed, Centrifugal, Condenser, Power (Triple or Deep Well).
 Pump—Simple Single Acting Steam, Sinking.
 Ram—Hydraulic.
 Steam Shovel.
 Stokers—Mechanical.
 Turbine—Hydraulic or Steam.
 Valve—Foot, Check, Gate—for Steam, Water or Gas.
 Valve—Relief, for Water—Safety, for Steam Boiler.

§ 233. Preparation of Outline for More Complete Specifications.

—The previous outlines are those necessary for the simplest form of specifications needed to secure intelligent proposals for the machines or apparatus desired. In most general specifications, and in all detailed specifications, a more complete outline should be prepared. This should include all of the various features and details

which the engineer decides should be properly included. These should be set down in logical order, and each main heading should be subdivided into each item which must ultimately be described. In general, such an outline should include:

First: The extent of the contract. This should describe briefly all of the items which are to be furnished under the proposed contract.

Second: The number, type, capacity, service and requirements of the machines desired.

Third: The foundation, erection and finishing.

Fourth: The appurtenances, tools, etc., to be furnished.

Fifth: The details of the machine as far as they are to be set forth.

Sixth: The drawings and specification to be submitted with the bid and to be made part of the contract.

Seventh: The guarantees and tests on which the purchase is to be made.

Eighth: The general requirements as to inspection, shipment, payments, etc.

The following outlines used by the author in his professional practice will give an idea of the arrangement suggested and the extras to be included in such outlines:

§ 234. Outline of Specifications for a Steam Boiler.

1. *Extent of Contract:*

A. Boiler.

B. Erection.

C. Valves.

D. Pressure gauge, gauge cocks and water columns.

E. Feed and blow-off pipes and connections.

F. Tools.

G. Grate bars.

H. Boiler accessories and appurtenances as specified.

2. Number of boilers.

3. Rating.

4. Type of boiler.

5. Contractors' specifications.

6. Details.

A. General dimensions.

B. Shell.

C. Tubes.

D. Material.

(a) Shell.

- (b) Tubes.
- (c) Rivets.
- E.* Workmanship.
- F.* Bracing—Flanges and connections.
- G.* Dome or dry pipe.
- H.* Manholes and handholes.
- I.* Wall brackets or other means of support.
- J.* Bending bars, rear arch bars, anchors, etc.
- K.* Furnace and grates.
- L.* Stoker.
- 7. Furnace settings and coverings.
- 8. Breeching, smoke connections, stack and stack plate.
- 9. Boiler fronts and floor plates.
- 10. Boiler accessories.
 - A.* Usual fittings:
 - (a) Safety valves.
 - (b) Steam gauge with siphon.
 - (c) Water gauge with standpipe.
 - (d) Gauge cocks.
 - (e) Whistle and pipe.
 - (f) Blow-off valve.
 - (g) Check valve.
 - (h) Stop valve.
 - (i) Gauges—steam and recording.
 - (j) Furnace tools.
 - B.* Piping.
 - (a) Steam pipe.
 - (b) Feed pipe.
 - (c) Blow-off pipe.
 - (d) Pipe covering.
 - C.* Feed pump.
 - (a) Size and type.
 - (b) Description.
 - D.* Feed water heater and purifier, exhaust head and connection.
 - E.* Injector and connections.
 - F.* Hot water meter and connections.
 - G.* Damper regulator.
 - H.* Coal cars—scales and track.
 - I.* Mechanical draft apparatus.
- 11. Erection.
- 12. Inspection and insurance.
- 13. Efficiency of boiler.
- 14. Test.
- 15. Guarantee.
- 16. Time of shipment, delivery or completion.
- 17. Payments.

§ 235. Outline Specification for Steam Engines.

1. *Extent of Contract*: The work to be done under this contract shall include:
 - A. The furnishing of.....steam engines.
 - B. To be delivered
 - (a) On foundations at.....
 - (b) Free on board cars at.....
 - (c) Free on board cars at factory.
 - C. The foundations for said engine shall be constructed by
 - (a) Contractor for the engine.
 - (b) The purchaser.
 - D. The engine shall be erected by
 - (a) The contractor for the engine.
 - (b) The purchaser.
 - E. There shall also be included all connections, tools, equipment, accessories and appurtenances as hereinafter provided.
2. *Capacity*: The engines shall each have a capacity of at least.....(indicated or actual) horse power.
3. *Service*: The engines shall develop the horse power above specified under a boiler pressure of.....pounds, and shall be designated to operate under boiler pressures ranging from..... pounds to pounds.
 The engine is intended to operate an (electrical generator, power pump, main shaft, etc.), which has a speed of.....revolutions per minute, (on which there will be placed a driving pulley inches in diameter by.....inch face), to which said engine is to be connected by (rope, belt, friction clutch, or direct connection).
4. *Type of Engine*: The engine shall be of the (slide valve, automatic high speed or Corliss) type, and shall have (single, compound or triple expansion) cylinders, and will be used (condensing or non-condensing).
5. *Drawings*.
6. *Specifications*.
7. *General Design*.
8. *General Dimensions*: The bidder shall furnish with his proposal the following dimensions of the engines on which his proposition is based:
 - Diameter of high pressure cylinder.
 - Diameter of intermediate cylinder.
 - Diameter of low pressure cylinder.
 - Length of stroke.
 - Revolutions per minute.
 - Piston speed per minute.
 - Size of steam pipe.
 - Size of exhaust pipe.
 - Diameter of fly wheel.
 - Weight of fly wheel.

Diameter of band wheel.

Weight of engine.

9. *General Details:*

A. Cylinder.

Material.

Lagging.

B. Valves.

(a) Steam.

(b) Relief or

(c) Safety valves.

C. Shaft.

D. Bearings.

(a) Main bearings.

(b) Outboard bearings.

E. Main rods.

(a) Connecting rods.

(b) Piston rod.

(c) Eccentric rod.

(d) Valve rod.

F. Pins:

(a) Crank pin.

(b) Cross head pin.

G. Governor:

(a) Shaft governor.

(b) Throttling governor.

(c) Automatic safety stop.

H. Cross head.

I. Cross head guides.

J. Crank shaft.

K. Fly wheel.

L. Frame.

M. Bed plate.

N. Sub-base.

O. Connections for power transmission.

P. Workmanship.

Q. Finishing.

10. *Furnishings:*

A. Foundations.

B. Foundation bolts.

C. Pipes.

(a) Steam pipes.

(b) Exhaust pipes.

(c) Drain pipes..

D. Throttle valve.

E. Separator.

F. Gauges.

G. Indicator connections.

H. Lubricators and oiling devices.

I. Tools, wrenches, etc.

J. Condenser:

(a) Class—jet or surface.

(b) Piping and connections.

K. Air and vacuum pumps.

11. *Erection.*

12. *Marks.*

13. *Tests.*

14. *Guarantee and insurance.*

15. *Time of Delivery.*

16. *Payments.*

§ 236. Outline of Specification for a Power Pump.

1. *Extent of Contract:* The work to be done under this contract shall include:

A. The furnishing of.....power pumps.

B. To be delivered

(a) On foundations at.....

(b) Free on board cars at factory.

(c) Free on board cars at.....

C. The foundations for said pumps shall be constructed by

(a) The contractor.

(b) The purchaser.

D. The machines shall be erected by

(a) The contractor.

(b) The purchaser.

E. There shall also be included all connections, tools, equipment, accessories and appurtenances as hereinafter provided.

2. *Capacity:* The pumps shall each have a capacity of at least (.....gallons per minute), (.....million gallons per day of 24 hours) at a piston speed of not to exceed.....feet per minute.

3. *Service:* The pumps shall be capable of pumping the quantity of water above specified against an ordinary (pressure of.....lbs. per square inch), (head of.....feet), or against a (fire pressure of.....lbs. per square inch), (head of.....feet for fire service).

4. *Type of Pump:*

A. Cylinders:

(a) Single.

(b) Duplex.

(c) Triplex.

B. Action:

(a) Double acting.

(b) Single acting.

5. *Efficiency.*

6. *Drawings.*

7. *Specification and description.*

8. *General design.*

9. *General dimensions.*

10. *General details of construction:*

A. Pump frame.

B. Water end:

(a) Plungers—speed, capacity.

(b) Stuffing boxes.

C. Water valve construction:

(a) Design.

(b) Valve discs.

(c) Suction valves.

(d) Force valves.

(e) Valve springs

(f) Valve seats.

D. Power end:

(a) Pinion shaft.

(b) Pinion and gears.

(c) Gear guard.

(d) Speed of operating motor.

(e) Size of driving pulley, friction clutch, etc.

(f) Revolution.

E. Connections.

(a) Connecting rods.

(b) Cross head and cross head guides.

(c) Main crank shaft.

F. Water connections.

(a) Hand holes.

(b) Air chamber and fittings.

(c) Vacuum chambers.

(d) Drip cocks.

(e) Air cocks.

(f) Air inlet.

(g) Priming pipes.

(h) Suction entrance.

G. Lubricators and oil cups.

H. Pipe sizes:

(a) Suction and discharge pipes.

(b) Small piping.

I. Foundation bolts.

J. Foundation.

11. *Painting and finishing.*

12. *Furnishings:*

A. Oilers and tray.

B. Tools.

C. Pressure gauge.

D. Gauge boards.

E. Revolution counter.

F. Relief valve.

G. Gate valve.

H. Check valve.

I. Connections.

13. *Erection.*

14. *Marks.*

15. *Factory tests:*

A. Of air chamber.

B. Of pump.

16. *Tests for acceptance:*

A. A test for smoothness of working.

B. Test for machine friction.

C. Test of tightness and strength.

D. Test of slip.

E. Test for maximum working pressure and delivery.

17. *Guarantee and insurance.*

18. *Time of completion.*

19. *Payments.*

§ 237. Outline for Specifications for Duplex Steam Pump.

1. *Extent of contract.*

2. *Class of pumps.*

3. *Description of pumps.*

4. *Drawings.*

5. *General design.*

6. *Service.*

7. *Material.*

8. *Construction of pumps.*

A. Construction of water end.

(*a*) Valve design.

(*b*) Valve disc.

(*c*) Suction valves.

(*d*) Discharge valves.

(*e*) Valve springs.

(*f*) Valve seats.

(*g*) Hand holes.

(*h*) Suction entrance.

(*i*) Air chambers.

(*j*) Vacuum chambers.

(*k*) Drip cocks.

(*l*) Air cocks.

(*m*) Priming pipes.

B. Construction of steam ends.

(*a*) Steam ports.

(*b*) Steam valves.

(*c*) Cushion valves.

(*d*) Clearance in cylinders.

- (e) Valve adjustment.
- C. Fittings.
 - (a) Piston rods.
 - (b) Valve rods.
 - (c) Water plungers.
 - (d) Stuffing boxes.
- D. Finishing.
 - (a) Lagging.
 - (b) General finish.
- 9. *Pipe connection:*
 - A. Suction and discharge.
 - B. Steam pipes.
- 10. *Furnishings:*
 - A. Oilers and tray.
 - B. Oil cups.
 - C. Tools.
 - D. Steam gauges.
 - E. Revolution counter.
 - F. Throttle valve.
 - G. Relief valve.
 - H. Cut-off valve.
 - I. Stroke gauges.
 - J. Connections.
 - K. Foundation bolts.
 - L. Foundations.
- 11. *Erection.*
- 12. *Marks.*
- 13. *Factory tests:*
 - A. Of air chambers.
 - B. Of pumps.
- 14. *Tests for acceptance.*
 - A. Test for smoothness of working.
 - B. Test for machine friction.
 - C. Test for tightness and strength.
 - D. Test for slip.
 - E. Test for maximum working pressure and delivery.
- 15. *Guarantee and insurance.*
- 16. *Payments.*

§ 238. Outline for Specifications for a Pumping Engine.

- 1. *Extent of contract.*
- 2. *Number and class of engines.*
- 3. *Service.*
- 4. *Duty.*
- 5. *General design.*
- 6. *Construction of pumping engine:*
 - A. General description.

- B. Frame work.
- C. Galleries.
- D. Steam cylinders.
- E. Lagging.
- F. Throttle valve.
- G. Steam separator.
- H. Condenser.
- I. Governor.
- J. Water end:
 - (a) Water way.
 - (b) Valves and valve disc.
 - (c) Plunger and plunger rod.
- K. Air and vacuum chambers.
- L. Air chamber fittings.
- M. Drip cocks.
- N. Air cock.
- O. Air inlet.
- P. Priming pipes.
- Q. Oil cups and lubricators.
- R. Indicator and connections:
 - (a) Indicators.
 - (b) Reducing motions.
 - (c) Springs.
 - (d) Scales.
 - (e) Planimeter.
 - (f) Connection.
- S. Foundation bolts.

7. *Furnishings:*

- A. Oiler and tray.
- B. Tools.
- C. Revolution counter.
- D. Pressure gauges:
 - (a) Standard.
 - (b) Recording.
- E. Gauge board.

8. *General workmanship and material:*

- A. Flanges.
- B. Nuts.
- C. Piping.
- D. Painting and finishing.

9. *Foundation.*

10. *Erection.*

11. *Marks.*

12. *Guarantee and insurance.*

13. *Time of completion.*

14. *Tests and acceptance:*

- A. Inspection and time allowed for tests.

- B. Tests for smoothness of workings.
- C. Tests for maximum working pressure and delivery.
- D. Duty tests.

15. *Payments.*

§ 239. **The Specifications.**—After the preparation of the outline previously described, the engineer should prepare with great care the specifications for the machine or appliance desired. All that has previously been discussed in regard to the writing of specifications should be kept fully in mind, and everything should be done to assure that the specifications shall be full and complete, clear and explicit. If the outline has been prepared with care, the attention of the engineer can be confined to the preparation of the specification in carefully worded and exact language which will assure a clear interpretation of his requirements by the elimination of all indefinite, indeterminate and ambiguous language, and if all arbitrary, unfair and unnecessary requirements are eliminated, he will be reasonably assured of low and intelligent proposals. The following statement of the requirement of general specifications and the examples given will still further illustrate the matter and arrangement suggested.

§ 240. **General Specifications for Machinery.**—When general specifications for machinery are to be issued they should include the following: (For examples under each heading see specifications following for steam engines and boilers.)

1. *Extent of Work.*—In this specification should be defined in general terms what is required under the contract, including:

- A. The furnishing of the machine, or number of machines required;
- B. The point of delivery;
- C. The preparation of foundations, and by whom;
- D. The erection, and by whom;
- E. The various furnishings, tools, fittings and equipment required with the machine.

2. *Capacity.*—Under this head, the capacity of the machine should be specified. This specification should define the amount, quantity or rate of work which the machine will be required to do or accomplish in a specified time.

3. *Service.*—Under this head should be included the specifications regarding the pressure or intensity under or against which the machine is to operate. This would include, in steam driven ma-

chinery, the steam pressure to be furnished to operate the machine, and in pumps, compressors or electrical generators, the pressure against which the machinery is to operate.

4. *Type of Machinery.*—In many classes of machinery, special types of machines are capable of operating with a greater or less degree of economy, and wherever possible the selection of the type of machine should be made by the engineer preparing the specifications, without necessarily entering into the details of construction. When the type is given, the variation in the bids received is largely limited, and the selection of machinery becomes more largely a question of price than where a large variety of types are considered.

5. *Furnishings.*—This specification should cover a description of the accessories, furnishings and fittings which are to be supplied with the machine in question; it should include any auxiliary machinery or apparatus and appliances which are desired and which are not normally a part of the machine.

6. *Design.*—This specification should cover the details of the machine which are either definitely specified or which are to be left to the manufacturer to select in accordance with his own practice. The elaboration of the specifications for type and design is the essential feature in which the detailed specification varies from the general specifications.

In general, the design of any machine should be—

“such that all working parts shall be readily accessible for inspection and repair, easily duplicated, and readily replaced, with each and every part of the machine properly designed and suitable for the uses and service required.”

7. *Drawings and Plans.*—This specification should describe the plans to be furnished by the bidder. These should usually include foundation plans, showing the general plan or outline of the machine, including its general dimensions, with the location of all connections, and this specification should also require the furnishing of catalogues or photographs showing the machinery under consideration in satisfactory detail.

A specification requiring the furnishing of detail working plans is not usually advisable. Most responsible manufacturers rightly refuse to part with such drawings which are largely the work of their extensive experience and are of too great value to be made public property.

In special work, however, or when the manufacturer is presenting a newly designed and untried machine, a requirement for the production of the detailed plans is often advisable, and may be necessary for safety. Such a requirement is useless, however, unless the engineer is sufficiently acquainted with machine design to be able to intelligently criticise the designs when so presented, and in other cases the reputation and experience of the manufacturer must be the main safeguard.

8. *General Guarantee and Insurance.*—Under this head should be included a clause similar to the following:

“The contractor guarantees the design, workmanship and material to be as described and specified herein, and also as described and specified in the detailed specification hereto annexed and hereby made a part hereof.

“He further guarantees that all work and all material in said machinery shall be of the best quality and first-class in every particular.

“He further agrees to replace any portion of said machinery shown deficient by the tests to be made on said machinery, or otherwise, or which shall within one year thereafter fail on account of being deficient in workmanship or material.”

9. *Detailed Specifications.*—This specification should require the manufacturer to furnish detailed specifications covering all features of the machinery, including workmanship and material, with such guarantees in regard to regulation, operation or economy as are to be required from him or given by him. Such specifications should be required to include specifications in detail of all furnishings to be supplied by him.

10. *General Information.*—Under this head the contractor should be required to describe with brevity the main dimensions of the important parts of the machine to be furnished, including the total weight of machine, weight of such parts as may be essential for comparison, revolutions or speed, and the various essential facts on which a comparison of the class of machinery to be furnished can be most satisfactorily made, including also time of delivery or of completion.

There should usually be included in the specifications, a list of the data required with blanks left to be filled out with same. By this means comparison and selection will be greatly facilitated.

§ 241. Specifications for Furnishing a Boiler.

1. *Extent of Contract.*—This contract shall include the furnishing of the following described boiler for, including all necessary accessories, as herein specified, and in accordance with the detailed

plans and specifications submitted by the contractor and accepted by the party of the first part, which plant shall include the following items:

A. The boiler complete.

B. The erection of the same, including furnishing all material and labor for the foundation and setting of the boiler.

C. All stop and safety valves and connections.

D. Nickel plated eight-inch (8") dial gauge and gauge cocks and water column.

E. The steam pipe to the engines, suitably covered and protected.

F. All necessary feed and blow-off pipes, valves and connections.

G. Fire, cleaning and other tools.

H. Track scale and hot water meter.

I. Shaking grate bars of acceptable pattern.

J. Stack connections.

2. *Number Required*.—There shall be one (1) one hundred and fifty (150) horse power boiler.

3. *Rating*.—The horse power of the said boiler shall be rated on an evaporation of thirty (30) pounds of water per horse power per hour under seventy (70) pounds of steam pressure, with feed water at a temperature of one hundred degrees (100°) Fahr., or the equivalent to such conditions. The boilers shall be designed to sustain a working pressure of one hundred and fifty (150) pounds.

4. *Type of Boiler*.—The boiler shall be an internally fired return tubular boiler, water tube boiler, or return tubular boiler.

5. *Description and Drawing*.—Detailed description and drawings, tracings or prints shall be furnished, describing and showing in detail the dimensions of all and every part of the boiler and the appurtenances thereof. Said descriptions and drawings shall show the size and thickness of all plates and pipes, the character of material from which all portions of the boiler are to be made; and said description and drawings shall indicate clearly, the construction and method of operation of all the details. These drawings shall comply strictly with the specifications, and the boiler when set and ready for use must conform strictly with the drawings as furnished by the contractor and accepted by the party of the first part.

6. *Furnace and Setting*.—The furnace shall be first class in every particular and of suitable design. The furnace and all parts exposed to the direct flames shall be lined with the best quality of fire

brick, set with two by eight inch face to the fire, and said brick shall be set in tempered fire clay. Boiler must be so designed and arranged as to prevent all unnecessary radiation and, if necessary, the boiler shall be set in a suitable air-tight brick setting and all exposed parts shall be covered with magnesia sectional covering.

7. *Front*.—Boiler front shall be of a neat and artistic design approved by the engineer. All joints, seats and faces shall be fitted closely and neatly.

8. *Pipe Connections*.—All pipe connections necessary for the operation of the boiler shall be made by the contractor and shall include all pipe between the boiler and the feed pump and between the boiler and engines. Said piping shall be so arranged that this boiler may be used independently or in connection with the boilers already in use, and in such manner that its use can be discontinued at any time and the other boilers used to operate any engine. Said piping shall be placed on plans approved by the engineer. All steam pipes shall be properly and thoroughly covered with magnesia sectional covering containing at least 80 per cent pure oxide of magnesia.

9. *Furnishings*.—There shall be furnished and installed with this boiler all necessary appurtenances for its care and management, including gauges, valves, etc., and all necessary fire and cleaning tools. There shall also be provided one track scale for weighing the coal used in the boilers. There shall also be installed on the feed water pipe, one hot water meter so arranged as to measure the amount of water fed to the boiler and also arranged so that it may be readily tested at any time.

10. *Inspection and Insurance*.—The boiler shall be inspected and insured by the Hartford Steam Boiler Inspection and Insurance Company, or some other first-class insurance company satisfactory to the party of the first part, for a period of one year, and a receipted bill for paid insurance and a certificate of inspection shall be furnished the party of the first part by the contractor.

11. *Efficiency of Boiler*.—The boiler shall give the efficiency guaranteed by the contractor in his proposal. Said efficiency shall be based on the evaporation of water into dry steam per pound of combustible from and at 212 deg. Fahr. temperature, when burning an average quantity of coal of the quality commonly used for boiler purposes at, or, when preferred, when burning any quality of such kind of coal as may be specified and furnished by the

contractor. In either case a continuous test of any duration up to twenty-four (24) hours may be made, and while running the machinery or otherwise, as the engineer may elect. Said test shall be made in conformity with the revised code of the American Society of Mechanical Engineers.

12. *Guarantee*.—The contractor guarantees the design and workmanship to be as described and specified in these specifications and in the specifications furnished by him and accompanying his bid for the work in question. He further guarantees all work and material in said boilers to be of the best quality and first-class in every particular. He further agrees to replace any portion of said machinery shown deficient in test or otherwise, or which shall within six (6) months thereafter give out on account of being defective in workmanship or material.

13. The contractor further agrees to have the plant complete and erected on foundations and ready for use by the day of, 19... Subject to the general form of the contract.

14. *Payments*.—One-third of the contract price for said boiler shall be due and payable when the boiler is received in apparent good order at One-third additional shall be due and payable after the boiler has been successfully tested in accordance with those specifications.

§ 242. Specifications for Furnishing a Steam Engine.

1. *Extent of Contract*.—This contract includes the furnishing and erecting a steam engine and appurtenances for, for use in operating a triplex power pump, also the various appurtenances and accessories described and specified herein, all to be in accordance with these general specifications and the detailed specifications and plans submitted by the contractor and accepted by the party of the first part attached hereto, marked "Exhibit D" and which are hereby made a part hereof.

2. *Plant Required*.—There shall be furnished one (1) steam engine of a capacity of ninety (90) actual horse power.

3. *Service*.—The engine shall be capable of furnishing the actual horse power above specified and shall be so rated at ninety (90) lbs. steam pressure. The engine shall be designed to stand a working pressure of one hundred and ten (110) lbs. and shall be capable of operation at full speed without shock or jar.

4. *Steam Consumption*.—This engine will operate for domestic service at about forty (40) actual horse power and must be designed

for economical operation at this rate. It must also be capable of furnishing ninety (90) actual horse power for fire service.

Economy for fire service is not so essential and will not influence the selection of the engine to the extent that the selection will be influenced by economy for domestic service. The steam consumption when delivering forty (40) actual horse power must not exceed forty-five (45) pounds of dry steam for each actual horse power delivered, and a guarantee of greater economy will have additional weight in the selection of the engine to be used.

5. *General Design*.—The design of said engine shall be such that all working parts shall be readily accessible for inspection and repair, easily duplicated and each and every part suitable for the use and service required.

6. *Description and Drawings*.—Detailed description, drawings, tracings or prints shall be furnished showing in detail the size of each and every part of the machinery and the appurtenance thereof, and the character of the material from which the same is to be made, and shall indicate clearly the construction of all details and the manner of working the same. These drawings shall comply strictly with the specifications, and the machinery must conform strictly with those detailed plans as furnished by the contractor and accepted by the party of the first part.

7. *Regulation*.—The regulation of speed shall be such that no variation in load from no load to full load shall vary the speed more than three (3) per cent with any boiler pressure between eighty (80) and one hundred and ten (110) lbs.

8. *Details*.—A. *Cylinder Lagging*.—The cylinder shall be covered with suitable non-conducting material to prevent radiation. This in turn shall be covered with suitable lagging which shall be properly mounted and shall accurately conform to the cylinder and steam chest.

B. *Connection for Power Transmission*.—The power shall be transmitted from the engine to the triplex pump which said engine is intended to operate, by means of a flexible coupling, which shall be under this contract and which shall be so arranged as to take care of any slight error in the relative alignment of the two machines without undue loss by friction or the heating of journals. The flexible coupling shall be of a design approved by the engineer.

9. *Indicator Connections*.—The engine shall be tapped for the indicator and shall be provided with a set of brass indicator pipes

with half-inch angle valve near each tap and pipes to lead to a half-inch standard thread three-way cock at about the center of the cylinder.

10. *Separator*.—The engine shall be provided with a steam separator of satisfactory design and of sufficient size to protect the engine from water in the steam. The drip of said separator shall be connected by one-half ($\frac{1}{2}$) inch brass pipe with a steam trap of approved make to be furnished by the party of the second part.

11. *Finishing*.—All unfinished iron work on said engine shall be well and thoroughly painted three coats of paint of acceptable color. All lagging shall be neatly finished and all brass work and polished work shall be finished in a first-class and acceptable manner.

12. *Pipes*.—A. *Steam Pipes*.—All steam pipes and openings shall be of ample size to prevent undue friction and loss of pressure. The steam piping within the engine room shall be furnished and placed by the contractor for the engine in a manner satisfactory to the engineer. All live steam pipe shall be covered by magnesia sectional covering in a satisfactory manner.

B. *Drain Pipes*.—All drain pipes shall be of brass, properly and neatly fitted and so connected as to conduct the drip into the sewer.

13. *Foundations*.—The contractor shall furnish necessary blue print or drawing showing the location of all foundation bolts and the form of foundation required for the engine which foundation will be furnished by the party of the first part.

14. *Furnishings*.—A. *Throttle Valve*.—A gate throttle valve with flange connections and of approved design and manufacture shall be furnished with the engine and attached to the steam supply pipe to the engine.

B. *Oiling Devices*.—There shall be furnished with the engine a one-pint sight feed lubricator with connections of approved pattern, also all necessary oil cups and arrangements for proper and thorough lubrication.

C. *Tools*.—There shall also be furnished with the engine all necessary wrenches and tools needed for the proper operation, inspection and ordinary repairs of said machinery. All tools to be of the best workmanship and material and satisfactory to the engineer.

D. *Foundation Bolts*.—There shall also be furnished the necessary foundation bolts to be of approved number, size, and length.

15. *Erection*.—The contractor shall erect the engine on the foundation provided, and shall connect the same with all appurtenances thereto, including all necessary steam fitting from the engine to the main steam pipe, and the equipment of said engine for active service. He shall also furnish a competent man to operate said engine during the test and to give instructions to the engineer of the party of the first part.

16. *Marks*.—The engine shall be suitably marked with the maker's name and the principal dimension of the cylinder and length of stroke; the plates containing said data to be of neat and artistic design.

17. *Tests*.—The test for efficiency will be made for a period of ten (10) hours. In the performance of said duty the steam pressure will not exceed one hundred (100) lbs. nor be less than ninety (90) lbs. per square inch. No deductions of any kind whatever, other than herein specified, shall be allowed in the estimate for capacity or efficiency. The failure of the plant to perform its duty during such test will cause the rejection of the engines unless the contractor shall make such alterations in said machinery as shall be necessary in order that it shall accomplish the specified duty. The efficiency and economy shall be calculated on the number of pounds of feed water used and on the basis of dry steam. The exhaust of the plant will be delivered into a feed water heater through which the feed water will be forced. The feed water will be taken from the reservoir. The tests shall be made by and under the direction of the consulting engineer.

18. *Guarantee*.—The contractor guarantees the design and workmanship to be as described and specified in these specifications, and in the specification furnished by him and accepted by the party of the first part for the work in question. He further guarantees all work and material in said machinery to be of the very best quality and first-class in every particular. He further agrees to replace any portion of said machinery shown deficient in the test or otherwise, or which shall within one (1) year thereafter give out on account of being defective in workmanship or material.

19. *Time*.—The contractor further agrees to have the plant complete and erected on foundations by the day of, 19.., subject to the general conditions in regard to time and completion set forth in the general form of contract.

20. *Payments.*—No payments shall be made until the plant is erected, tested and accepted, and if the engine shall not prove in the specified test equal in all particulars to the guarantee, then and in that case, the party of the first part shall have the right to use such plant for a period of time sufficient to allow them to purchase and erect another plant of satisfactory design, and the use of such rejected plant under the conditions above named shall be without expense to said party of the first part otherwise than the cost of operating the same.

The agreed price will be paid by the party of the first part when the plant is tested and accepted.

§ 243. *Selection of Machinery.*—In the selection of machinery or apparatus it is usually desirable, so far as practicable, to choose those designs which have actually been developed and which have proved satisfactory by actual use under wide range of conditions. The use of the new designs which have recently been developed, even by those who have had extensive experience with similar designs but of a different kind or capacity, is attended with considerable risk. One of the early personal experiences of the writer will perhaps serve as a typical illustration of the unfortunate results of the failure to observe this precaution.

A factory was built for the manufacture of certain clay products from which a somewhat unusually large capacity was desired. Machinery was available from two sources. In one case, the manufacturer had a large number of machines of the capacity required in successful operation under a wide range of conditions; in the other case, the second manufacturer had many similar machines in local and successful use, but of only one-half the capacity required. The second manufacturer desired to develop a machine of greater capacity and pointed out their wide experience with the smaller machines and the ease and safety with which they could enlarge the capacity and develop a machine which should be perfectly successful. This they agreed to do at a price of less than one-half the price demanded by the first manufacturer. The development appeared so simple that the lower bid was accepted, and the machine manufactured and installed. The results were a season spent in a constant repair of breakage, and consequent shutdowns, occasioned by improper design. The output of the factory was decreased for the season by at least one-half, and although the manufacturer finally designed a satisfactory machine and furnished a new unit to the factory without further compensation, the delays and repairs exceeded the original cost of the machine many times and entailed a heavy loss which

might have been eliminated if the more expensive but fully developed machine had been selected. The second manufacturer learned how to design and construct his machine at the expense of the factory which used the first design. Such experience is not uncommon. Experience must be paid for, and it is usually much more economical for the individual to pay for the experience of others by a higher cost of equipment than to pay the larger expense of personal experience.

Guarantees of replacement of a machine, should it prove unsatisfactory, are often easily obtained but it is seldom that a manufacturer will undertake to pay the consequent damages, and the prospect of such damages when an undeveloped machine is adopted, is usually too great to warrant its installation even at a greatly reduced price.

CHAPTER XX

DESIGNS AND SPECIFICATIONS FOR ENGINEERING AND ARCHITECTURAL WORK

§ 244. **The Investigations.**—Prior to the design of any plant or structure a thorough investigation should be made of the nature of the material which must be excavated or moved, of the foundation on which the structure must rest, and of the material into or through which tunnels, channels, foundation piles, caissons or other structures must be driven. The character, the quantities and the physical conditions of such materials should be determined so far as practicable. It is often the case that the decision to build or to carry out an improvement is followed immediately by a demand for construction at such an early date that a proper examination of the conditions is not possible. Such haste in construction is undesirable and almost invariably entails extra expense.

The failure to make suitable investigation of these conditions and to secure the desirable information, both for the use of the engineer in designing and estimating the cost of the work and for the use of the bidder in the preparation of his proposal, is often due to false economy on the part of the owner or of the management of the company who proposes to construct the work. The cost of thorough preliminary investigation is often considerable, and it is sometimes assumed that any extensive preliminary examination is unnecessary. When the engineer yields to necessity or persuasion and fails to secure the proper information, he is nevertheless blamed for any trouble and expense which may follow. If the bids received, based on insufficient information, are unduly high or if the quantities estimated on the same uncertain basis are found seriously in error, he is blamed for troubles which he has had no means of preventing.

Preliminary information will permit plans to be drawn to fit the actual local conditions, instead of assumed conditions which do not obtain and will save needless expense and much more than enough to pay the preliminary costs, to say nothing of the effect of such information in reducing the prices bid for the work. The engineer, therefore, should place the necessity for such preliminary investigations and the advantages which will accrue therefrom squarely before his clients, and insist on sufficient time and expenditure to secure the information

necessary for both purposes. The low bids received on almost every job on which adequate information is furnished by the engineer to prospective bidders is proof of the saving effected in the cost of the work, and this is in addition to the saving accomplished by the consequent proper design. Everything that can be done to make the conditions bearing upon the required work clear and certain has an advantage in reducing the prices which will be bid for the work, and the converse is also true.

§ 245. **Unsatisfactory Practice.**—It is unfortunately common mistaken practice to require the contractor to assume all risk and responsibilities concerning the character and sometimes even concerning the relative amounts of the different kinds of material.

Good sense seems to warrant the conclusion that, in dealing with intelligent men something cannot be secured for nothing, and experience has demonstrated that whenever such an attempt is made it usually results in unnecessarily increased cost.

An intelligent contractor, if he bids at all on plans and specifications which are uncertain or manifestly unfair, will add a sufficient sum to compensate him for the uncertainties and the unfair treatment he must expect, and to be safe will usually add more than enough to cover the probable expense. The client thus pays more, and usually much more, than he would under definite plans and specifications.

When only incomplete investigations have been made by the engineer, contractors are usually invited to make their own investigations in order to determine the nature of the formation in or through which the work is to be built. It is evident that such a policy is a poor one, for if carried out it involves considerable expense perhaps for each of a large number of contractors, all of whom must investigate the conditions to their own satisfaction. It is evidently desirable in order to avoid expense that only one such investigation should be made, that it should be made by the engineer of the parties letting the work and that it should be thorough and sufficient for the use of all parties interested. This question is an important one and one that has many bearings, all of which should be considered. That such unfair and unsatisfactory practice is quite common is evident from numerous specifications of which the following from a proposed contract for grading a railroad is an example:¹

“Contractors bidding on the work are invited, at their own cost and expense, to put down test holes or borings, to determine the nature of the soil

¹ See Eng. News Sup., Vol. 50, page 29.

and underlying formation, and every facility will be given by the company to the contractors for that purpose."

"It must be particularly understood that the bidding on this work will be without classification for excavation and grading, and that the contractor must personally examine the geological formation; and no claim upon the company may hereafter be made on account of misinformation stated to have been given by any employee of the Company or Board."

It is evident that no intelligent contractor will assume uncertainties such as are involved in the above specifications without considerable investigation and without expecting adequate compensation. A conservative contractor will probably refuse to undertake such an investigation, because the chances of his securing the work are remote. The number of firms that will attempt to make such an investigation will therefore be small and the competition will be limited. Such firms will bid high enough to cover the cost of all possible contingencies, and the cost of the work will be unnecessarily increased.

§ 246. **Difficulties.**—To make a thorough investigation of the actual conditions on a project, to determine the quality and quantity of the various kinds of material to be encountered and to show them by plans, drawings and definite specifications, involves not only time and expense but also the responsibility for any accidental misstatement of the exact facts. Underground conditions are very uncertain and cannot be readily determined even by elaborate borings. Variations in the strata are liable to occur which will not be determined even though the borings are fairly close together and it is evident that such investigations must have a practical limit. Any departure from the positive information given may result in demands for extra compensation, and even slight variations which might not actually affect the cost of the work will give an unfair contractor an opportunity for excessive demands for extra compensation; whereas if the contractor is required to assume the responsibility for changes, no such claims can be maintained. It is believed that this danger is one of the chief reasons why so much responsibility is frequently forced on the contractor, even when it is recognized that such responsibility entails extra expense.

It is desirable to remove hazard to as great a degree as practicable, both in order to secure reasonable bids and for the sake of fairness. The owner must expect to pay a fair price for his construction under the conditions that actually obtain, and he will certainly be compelled to do so unless some mistake is made by the bidders. The technical problem involved is to determine and show by plans and specifications as nearly as possible the actual conditions that obtain in order to se-

cure low prices through protection to the contractor in his bidding, and to protect the owner from unjust claims based on slight variations which do not affect the cost. This can often be done by determining the quality and kinds of material through sample borings and by arranging to pay for possible variations in estimated amounts in accordance with their actual occurrence.

In the excavation of trenches, tunnels, etc., a large item of expense is the cost of handling the water that may be encountered. In many specifications the contractor is required to take the risk as to what this may cost. The removal or reduction of the risk is a relief to the contractor and will usually reduce the price bid for the work. Such a clause in tunnel work is occasionally introduced essentially as follows:

"The contractor will be required to pump out of the upper section of the tunnel, 10,000 gallons per day of 24 hours, without charge, regardless of the amount of lift. Any excess of water will be paid for at the rate of 1,000 gallons specified in the proposal."²

The last sentence in the above specification is objectionable on account of the fact that the amount of the excess water cannot well be estimated, and therefore no basis of comparison of various bids is possible on this item. It would apparently be better to state in the specification an amount which will be paid to contractors for each 1,000 gallons, although such a specification would probably be illegal in public contracts where the work must be to let the lowest responsible bidder.³

Under such contracts, in all cases where the cost of any extra work is fixed at cost plus a percentage, or where provision is made for any incidental rock excavation or other contingent expense, at a certain fixed price per unit, the payment for such work can be enjoined by a taxpayer. The only safe method therefore under public contracts is to ask for a percentage bid for extra work or for a unit price for any other contingent expense.

§ 247. **Deep Wells.**—In some cases, a complete investigation is evidently inexpedient. For example, in deep borings and in the drilling of deep wells, while the nature of the geological strata can in general

² See Eng. News, Vol. 52, p. 363.

³ "When the law provides that the contracts for public work shall be let to the lowest responsible bidder, any provision in the contract which fixes the price for extra work without having invited bids on that item, is illegal, and payments at rates specified may be enjoined at the suit of the taxpayer."—*Moynahan v. Birkett*, S. P. 2, Dept. 31, N. Y. Supreme Court 293

be ascertained, these strata are known to vary to a considerable extent in character and thickness from point to point and no means of accurately determining their exact nature and extent are available except by the construction of the well itself or a smaller one in the immediate vicinity which would involve an expense very greatly in excess of the benefit derived. In such cases, therefore, a statement of the approximate geological conditions seems desirable and, in general, the contractor should expect to take the risk of the uncertainties in the characters of the strata, and for which he must demand proper compensation. Provision should be made for the possibility of encountering caving material, for which contingency extra expenses may be occasioned by the necessity for enlarging the well and casing off the caving material in order that greater depths may be reached with the desired well section. It will usually prove economical for the owner to assume the responsibility for this extra expense, for if he does not he will probably pay the extra cost in higher prices, whether or not the expense is actually incurred.

§ 248. **Investigations for Sewers.**—In investigations for sewers the nature of the material which will probably be encountered is usually determined by borings or soundings. Such materials are often classified similarly to those in railroad excavation, and on this basis payments are ordinarily made. This limits the chances taken by the contractor and to a much greater extent than where he is left to estimate the varying amounts of such materials on the basis of the borings which have been made. The unevenness of the strata throughout the extent of the sewer system is so great that it is usually inexpedient to take sufficient borings to determine with accuracy the amount of rock which will be encountered. The variations in rock should not be at the risk of the contractor so far as amounts are concerned, and the expense incurred in making the necessary borings will be more than returned by the lower cost.

A clause in which the burden is thrown upon the contractor is as follows:⁴

"The Borough does not warrant the correctness of the soundings as marked on the profile. The contractor must assume all risks resulting from any difference from the soundings found to exist when the sewer is built."

In sewer work, the greatest item of uncertainty usually arises not through the question of rock or earth, but from the variation in the qualities of soil and through the presence of water. These materials

⁴ Eng. News Sup., Vol. 50, p. 305.

may consist of: (1) earth more or less easily caving; (2) earth or clay consolidated and free from cavings; (3) sand with or without water; (4) fine sand or quicksand and water.

It is usually inexpedient for the engineer to offer the above classification, and the questions of these materials and conditions, while they should be determined as clearly as practicable and given to the contractor as data for use in preparing his bid, must usually be at the contractor's risk.

§ 249. **The Basis of Designs.**—In every technical endeavor the object involved is the accomplishment of certain definite results at a minimum expense, either immediate or ultimate. If a structure is to be built both utility and a certain degree of beauty are usually involved. If permanent, it should not be unsightly, and its utility may demand any degree of artistic development from a plain but slightly structure to those structures which are created only for their artistic merit. In each case, however, the object is to accomplish the maximum of utility for the minimum of expense. No unnecessary expense is warranted. The structure must be safe and the degree of safety must be measured by the possible disastrous results of failure. Factors of safety must be introduced and are made necessary by variation in strength of material, uncertainties of manufacturing processes and uncertainties of loadings and consequent strains to which the structure may be subjected and to various contingencies to which it may be exposed. The limitations of strength, and the extent to which artistic considerations will prevail will always be a question of experience and judgment, and while these should be fixed with intelligence, in most cases a doubt may remain as to whether their limits are too small or too great. Safety must be balanced against expense, and the expense considered must always involve both first cost and upkeep.

In operating plants, questions of efficiency also arise; first cost and upkeep are important, but the running expense must be considered, and greater expense of installation and maintenance may be warranted by greater or more satisfactory output. In all cases, a balance between expense and results must be struck and the technical man is responsible for establishing a proper equilibrium between these various factors.

§ 250. **Design.**—To properly design any structure or plant the designer must be familiar with the methods which must be used in construction in order that the construction shall be practicable and can be economically performed. The design and the consequent specification should not include unnecessary refinements or unreasonable re-

quirements that will add to the expense without giving corresponding benefits. The design will have a large effect on the cost of construction and this fact should be duly considered before arbitrary and unusual details are finally adopted. Designs should be based upon the consideration of first cost, the cost of maintenance, and in certain cases, the cost of operation as well. Low first cost should not be secured at the expense of high maintenance or high operating expense but true ultimate economy should be considered whenever practicable. In some cases temporary construction may be necessary to secure the ultimate ends, and permanent construction can only follow with the development of the property. In plants which are to be maintained and operated there is a personal equation which must be considered. Who will operate and maintain the plant or structure? The capacity and ability of those on whom dependence must be placed for this purpose, needs careful consideration. High grade machinery and difficult maintenance must not be trusted to incompetent men and where inefficient assistants must be utilized for such purposes, simplicity of design is highly essential. In the arrangement of an operating plant the same factors must be considered. If the plant is so arranged that the easiest thing to do is the right thing to do, it may confidently be expected that it will be done but not otherwise. It is not enough that a plant be well and economically designed and carefully constructed. It must also be easily maintained and readily operated by the class of men that can be secured for such purposes, and these factors are equal in importance to the other physical factors in shaping the design.

The study for a design requires an extensive investigation of the various types of similar development that are in practical use and the adaptability of such designs to the conditions of the particular locality under consideration. It is seldom that plans, no matter how successfully carried out in one place, can be duplicated to advantage in another. Each plant should be built to meet the particular conditions under which it is to be installed, maintained and operated, and the best ideas from all sources that will apply to the local conditions should be correlated and embodied in the proposed design. Extensive experience, observation, and study are each desirable and essential for the best results.

The structure when completed should be suitable in every way for its purpose but no unnecessary expense should be incurred. The best of everything is not always essential or desirable.

“Reduction of first cost to the lowest possible point is in logical or economical order the first consideration; although therefore not by any means either the most important or the governing consideration. That this is so is easily seen, however often forgotten. It is not only businesslike common sense for investors and their servants, but it is sound political economy for the community as a whole. It does not mean nor imply cheap and shabby construction. It simply means an avoidance of waste, either in saving money or in spending it. It simply means a recognition of the fact that every dollar and every day's work that goes into the ground and does not bring something out of it, makes not only the individual but the whole community poorer.”⁵

For his own as well as for his client's good, the engineer should endeavor to secure the very best results possible when all things are carefully weighed and considered. No reasonable amount of conscientious work, painstaking thought, study, labor or expense should stand in the way of such results; and anything less than this is a detriment to future professional attainments, which no engineer, young or old, can afford.

§ 251. **False Economy in Design.**—In the building of shafts and tunnels, the cost of excavation and filling beyond the neat lines of the exterior of the lining is sometimes an item of considerable importance. In many cases, designers limit the excavation to these neat lines and in consequence the specifications require the contractor to assume all risks of extra excavation and filling and the extra cost must therefore be included in some other item of the proposal. In some cases, specifications are so drawn as to divide the risk by inserting a clause providing that any excavation beyond the neat lines, due to unavoidable falls and breaks, shall be paid for at a price which is usually named a little less than the actual cost to the contractor.⁶ By such means the contractor is assured of a certain compensation for all excavation and re-filling, but at a rate which will not make it an object to go beyond these lines on account of a high price for the required filling.

In other cases the entire risk is placed on the contractor.

In the specification:

“Concrete lining will be placed throughout the tunnel as indicated by the drawing. Any excavation beyond the neat lines of the tunnel section as shown on the drawings, shall be filled to the satisfaction of the engineer and no allowance will be made therefor.”

⁵ A. M. Wellington, *Eng. News Sup.*, April 28, 1904, p. 326.

⁶ See *Eng. News*, Vol. 52, p. 362.

not only is the risk placed on the contractor but the wording is indefinite and therefore unsatisfactory. The nature of the filling should be stated, whether clay, rock or concrete. It is easy for the engineer to here specify the character of the material that will be required and leave out the doubtful term "satisfaction."

It should be remembered that, while throwing the cost of this extra fill on the contractor may be an apparent saving in the cost of the work, in order to keep down the amount of additional extra work, extra cost may be involved. Extra cost may be caused

First: By drilling holes.

Second: By the cost of powder and labor required to break rock to small size for loading.

Third: By the cost of trimming projections from the side of shaft or tunnel.

What is desired is the construction of proper work at the least expense to all concerned, and the cost of a reasonable amount of breaking beyond the neat lines may be more than saved in reducing the extra cost of careful excavation. The above is but a single example of how false economy may sometimes be attempted in the preparation of designs and specifications.

§ 252. **Estimates.**—Estimating the cost of structures and material is an important duty of the engineer. The financial success depends on the actual cost of such works and the works must be financed on the basis of these estimates. If the actual cost greatly exceeds the estimated cost, a project which may have seemed financially attractive may prove a financial failure; and even if failure does not result the necessary refinancing may prove an expensive handicap.

Plans are rarely made for large and important structures that do not require more or less modification during construction. Unless this fact is duly appreciated by the designer and liberally allowed for in the estimates of cost, the estimates will always be found more or less inadequate to complete the structure. The hazards of construction increase with the difficulties of construction. In the superstructure of one of the large buildings of Chicago, designed by one of the best architects of that city, and which was completed without any serious mishaps, the cost of extras increased the original contract price almost twenty-five per cent., or about \$700,000 on a \$3,000,000 estimated cost.

Engineering structures are sometimes built in locations where they are subject to considerable hazard due to conditions that cannot

be fully predetermined and to the contingencies of storm and flood, which cannot be foreseen. In such cases the ultimate cost cannot be accurately determined and is frequently greatly underestimated.

The engineer designing a structure or plant, if unfamiliar with the contingencies of actual construction, can scarcely conceive the unforeseen circumstances which may and frequently will occur when his plans are being carried out in the field. An estimate in detail of the reasonable cost of each feature of the work can seldom cover all the costs involved in the construction of such structure and the cost must be overestimated or a large contingent estimate must be added in order to cover the actual cost. An engineering project which will pay only fair returns on a close estimate of cost, is seldom worthy of serious consideration as unforeseen expenses will often make it a losing investment.

In a recent water power development which was under advisement for a number of years, and which was perhaps as thoroughly considered and as carefully planned, both in design and in methods of construction to be pursued, as any other development of late years, the cost of the finished project exceeded the estimate by thirty-three per cent. The estimate of cost was about \$21,000,000; the actual cost about \$28,000,000. In another case, where estimates were carelessly made, the original estimated cost was \$800,000, and the actual cost of the complete development about \$2,500,000.

It is of course obvious that a project which may be very attractive on a basis of an investment of \$800,000 is likely to be a serious failure on the basis of an investment of \$2,500,000; and even a project which seems attractive on the basis of a \$21,000,000 investment may be seriously handicapped by an expense of \$28,000,000 unless there is a prospect of extraordinary returns on the basis of the original estimated cost.

The unexpected extra costs of such developments, due to unforeseen delays in construction, are often serious. The interest on bonds must be met semi-annually or annually from the date of their issue; hence interest during construction is an important item in the building of any structure or in the cost of development of any industry, and is an item which is particularly uncertain in hazardous construction. In a recent water power development a flood, the most extraordinary that had occurred on the river within the known records, not only caused a loss of approximately \$40,000 to the work under construction, but was followed by continuous and unusually high water for the

year following, so that not more than ninety working days were available within the year. In the same project, an ice jam in the spring carried out all the trestle and false works, involving a loss of perhaps \$10,000 more. These casualties created a delay of more than a year with an extra interest cost of approximately \$100,000.

From the above it becomes apparent that all estimates should be liberally made, and that if the financial feasibility depends on a very limited expenditure, the estimates must be made with the greatest of care.

Office engineers who have had little or no experience in the field cannot readily appreciate the contingencies of actual construction. Floods, storms, accidents, unavoidable delays in the receipt of materials, scarcity of labor, strikes, etc., have comparatively little meaning in the office but they are very real in the field and will constantly occur and add an unanticipated cost to office estimates. These contingencies are a real part of the cost of the work and just as much a part as the cost of material and labor and consequently must be taken into account in the estimates.

Published cost figures are often unreliable or misleading. In the first place the conditions are not sufficiently defined to assure an understanding of what estimate of cost the figures actually include, and they frequently omit general supervision and general and overhead expenses. In the second place such figures are seldom given unless they are comparatively low. If work has cost an excessive amount the cost figures are not a matter for congratulation and are seldom published. Such figures when used must, therefore, be used with discretion and must be substantiated by inquiries made to determine their applicability to the case in hand.

Besides the local physical conditions which must be considered in estimating the cost of construction, there are other factors peculiar to each locality that should be considered. In large cities labor is more plentiful but wages are apt to be higher and labor troubles more numerous. The cost of materials, wholesale, is not greatly different in the large or small community. Other difficulties due to municipal restrictions, such as traffic obstruction, etc., are much greater in the large than in the small city. The consequent cost of doing work is therefore frequently greater in the large city, and this is particularly so in regard to subsurface work.

Distance from the market for labor and material will also affect the cost. It is frequently difficult to secure and hold labor at points far remote from cities and delays and extra expense results.

Accurate estimates can only be based on a somewhat extended practical experience in actual construction work. The young engineer should begin at an early date to secure data of the actual cost of the work which he sees performed, and in so doing should take into account the general and overhead expenses which are not as apparent but are no less real than the actual work and material which are placed in the structure or work.

Even personal experience is apt to be misleading. Those who have had experience on difficult and expensive work will overestimate the cost of work where few difficulties or contingencies are involved, and the reverse is equally true and more dangerous to the estimator. The contractor who is used to doing work in large cities can seldom successfully compete with others for work in the smaller cities, and contractors who have been doing work in the smaller places are apt, unless great care is used, to underestimate the cost of work in large cities and to accept losing contracts on account of their lack of appreciation of the much greater cost involved.

§ 253. **Specifications.**—The subject matter of which the specifications for architectural work and for engineering structures and plants are to treat should include:

A. The materials, supplies and machinery to be furnished.

B. The work to be done.

C. The methods to be employed in furnishing material or in performing the work.

D. The results to be accomplished.

In general, the logical arrangement of specifications will call (1) for the description of the work as a whole, and (2) for the description of the same in detail and in the logical order of its construction, so far as this can be done, and still complete the detail specification of each part when the description is once begun. In general, the logical arrangement will be.

A. General description.

B. Foundation or principal features. (*a*) Accessories or specific details.

C. Substructure or secondary features. (*a*) Accessories or specific details.

D. Superstructure or general details. (*a*) Accessories or specific details.

E. Ornamentation and finishing as a whole and in detail.

The main subdivisions of any work should also be described in

general and in detail. The general description should, in all cases, be sufficient to afford a general knowledge of the work or portion of the work under discussion. The detail specifications should be confined to individual features and, in their description, should be exhaustive.

In general, such specifications are made up of specifications for fundamental materials, processes, and for machinery, and all that has been previously stated in regard to those subjects applies to the complete structures, plants or works of which they constitute the elements.

Such specifications may include both general and detailed specifications, and in all cases require a considerable special technical experience and knowledge in their preparation.

§ 254. **Outline.**—Preceding the preparation of specifications for complete structures an outline should be prepared including all items which should be covered in the required specification. As these structures are even more complicated and contain a greater amount of detail than the subjects heretofore discussed, such an outline becomes even more important in order that the specifications when prepared shall include all necessary requirements. The outlines shown in Appendix A will give the idea of such outlines as developed by the author in his professional practice.

§ 255. **Assignments for Preparing Outlines and Specifications for Engineering and Architectural Work.**—For the purpose of giving more point and interest to the work of preparing specifications for engineering or architectural works, it is desirable that assignments be based on actual plans for such works. These plans should be in sufficient detail so that the requirements can be clearly distinguished. For student practice the plans selected should be for simple structures as being more nearly within the capacity of the student. Even such simple structures will be difficult for the beginner, and the complicated subjects often assigned are so entirely beyond their comprehension and ability that they simply result in the unintelligent copying of other specifications and little consequent benefit to the student.

For purposes of assignment, a number of drawings of simple structures are given in the Appendix C. A few of these drawings are more elaborate and involve a number of parts into which they may be subdivided. In this way, the preparation of a more elaborate specification can be undertaken by several students, and the idea

can be made manifest that all elaborate specifications consist simply of a number of more or less simple parts or features joined together in a consistent and complete whole.

Besides the drawings of simple works given in the Appendix, there are occasional plans of simple structures published in the technical press in form sufficiently complete to afford a fairly satisfactory basis for the writing of specifications.

The following list contains a few references to such drawings.

§ 256. Plans from which Specifications may be Prepared.

		Page
A Superstructure for a Turn Table.....	Eng. Rec., Vol. 71,	290
Bulkhead to Protect Points on New Jersey Sea Shore	" " " 71,	547
Leads for Drilling Outfit.....	" " " 71,	725
Standard Gate House for 36" Valve on Steel Pipe Line	" " " 72,	407
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Hollow Concrete Dam	" " " 74,	1032
Concrete Lamp Post	" " " 74,	989
Stone Fill Timber Crib Bulkhead.....	" " " 74,	740

APPENDIX A

§ 1. Outline of Specifications for the Construction of a Building.

I. *Extent of contract:*

General description of work and material to be furnished under the contract.

II. *Estimate of quantities:*

Approximate or exact quantities and kinds of work and material.

III. *Plans and Drawings.*

IV. *Engineering work-lines, grades, etc.:*

V. *Special work.*

VI. *Materials:*

A. Furnished by the owner delivered where.

B. If furnished by the contractor:

1. (a) Cement.
- (b) Sand.
- (c) Gravel.
- (d) Water.
2. Steel, reinforcing.
3. Steel, structural.
4. Brick:
 - (a) Common.
 - (b) Face exterior.
 - (c) Face interior.
 - (d) Glazed or decoration.
5. Rubble stone.
6. Cut stone:
 - Dressed.
 - Polished.
7. Tile:
 - (a) Wall.
 - (b) Roof.
 - (c) Floor.
 - (d) Coping.
 - (e) Decorative.
8. Lumber:
 - (a) Rough.
 - (b) Dimension.
 - (c) Finishing.
9. Piling:
 - (a) Bearing.
 - (b) Sheet.
10. Plaster.

11. Doors:

Exterior.

Interior.

12. Windows.

13. Roofing.

14. Flashing and sheet metal work.

15. Lighting:

(a) Conduits.

(b) Switches.

(c) Outlets.

16. Piping:

(a) Gas.

(b) Water.

(c) Steam.

17. Power and heating plant.

VII. *General furnishings:*

A. Scaffolds, ladders, hoists and other equipment incidental to the proper execution of the work.

B. Rough hardware:

Nails, spikes, bolts, straps, etc., incidental to the construction.

C. Blocking.

D. Bond timbers.

E. Wood centers, templets, forms, etc.

F. Temporary covers for door, window and other openings.

G. Workmanship.

H. Inspection.

I. Cleaning premises after completion of work.

VIII. *Foundations:*

A. Preparation of site:

1. Removing existing structures, etc.

2. Grading.

B. Excavation:

1. Earth.

2. Rock.

3. Other excavation.

4. Blasting.

5. Disposal of excess material.

6. Ownership of excess material.

C. Piling.

D. Sheet piling, shoring, bracing, etc.

E. Caissons.

F. Grillage.

G. Footings.

H. Concrete.

I. Grouting.

J. Mason work.

K. Protection of existing property:

1. Responsibility for injury to.

L. Backfilling:

1. Tamping.
2. Puddling.

IX. Floors and ceilings:

A. Concrete:

1. Plain.
2. Reinforced.

B. Tile.

C. Structural steel work.

D. Lumber—carpenter work.

E. Openings.

F. Columns:

1. Covering.

G. Girders:

1. Covering.

H. Finishing:

1. Concrete surface.
2. Finishing and painting.
3. Granitoid.
4. Tile.
5. Polished stone.
6. Wood and finish.
7. Other surfaces.

I. Plastering under side or other finish.

J. Suspended ceilings—plastering, etc.

X. Walls:

A. Outside walls:

1. Concrete.

2. Brickwork:

a Common brick.

*a*₁ Selected brick, bearing brick, etc.

*a*₂ Bonding.

*a*₃ Jointing.

*a*₄ Mortar.

b Face brick.

*b*₁ Bonding:

Straight wall.

Around openings.

Trimmings and belt courses.

*b*₂ Jointing.

*b*₃ Mortar.

3. Stucco—outside plastering.
4. Structural steel.
5. Terra cotta and cut stone.
6. Lumber.
7. Openings:
 - (a) Window.
 - (b) Door.
 - (c) Special.
8. Cutting and patching.
9. Cleaning and painting.
10. Lathing, furring and plastering.
- B. Partition and interior walls:
 1. Tile.
 2. Metal lath and plaster.
 3. Concrete.
 4. Wood lath and plaster.
 5. Brick.
 6. Face brick—Interior decoration brick.
 7. Stone.
 8. Composition.

XI. *Windows:*

- A. Sash.
- B. Frame.
- C. Trim.
- D. Glazing.
- E. Operating services.
- F. Hardware:
 1. Locks.
 2. Hinges.
 3. Weights and rollers.
- G. Sills.
- H. Lintels.

XII. *Doors:*

- A. Door.
- B. Frame.
- C. Trim.
- D. Glazing.
- E. Hardware:
 1. Locks.
 2. Hinges.
 3. Rollers.
 4. Track.
 5. Checks.
- F. Threshold.

XIII. *Roof:*

- A. Concrete.
- B. Tile.
- C. Composition.
- D. Shingle.
- E. Tin or iron.
- F. Structural steel.
- G. Timber.
- H. Skylights.
- I. Ventilators.
- J. Air shafts.
- K. Drains:
 - 1. Gutters.
 - 2. Downspouts.
- L. Flashing:
 - 1. Openings.
 - 2. Chimney.
 - 3. Ventilator.
 - 4. Pipe outlets, etc.

XIV. *Stairways:*

- A. Iron or steel.
- B. Concrete.
- C. Stone.
- D. Wood.

XV. *Railings:*

- A. Iron.
- B. Wood.

XVI. *Platforms:*

- A. Iron.
- B. Concrete.
- C. Wood.

XVII. *Finishing:*

- A. Carpenter work.
- B. Plastering.
- C. Outside painting:
 - 1. Mixing paints.
 - 2. Stopping, filling and puttying.
 - 3. Staining.
- D. Interior finishing:
 - 1. Painting:
 - (a) Mixing paints.
 - (b) Filling, stopping, puttying.
 - (c) Staining.
 - (d) Varnishing.
 - (e) Decorating.

XVIII. Plumbing:

- A. Cast iron pipe and fittings.
- B. Wrought iron pipe.
- C. Vitrified pipe.
- D. Other pipe:
 - 1. Lead.
 - 2. Brass.
 - 3. Plated.
- E. Pipe joints.
- F. Fittings and valves.
- G. Fixtures, traps, etc.
- H. Ventilation risers.
- I. Supply pipe.

XIX. Lighting:

- A. Wiring and conduits.
- B. Piping, valves and connections.
- C. Switches and outlets.

XX. Heating:

- A. Furnace.
- B. Boilers.
- C. Piping:
 - 1. Steam or hot water.
 - 2. Sheet metal.
 - 3. Pipe covering.
 - 4. Valves.
- D. Radiators.
- E. Registers.

§ 2. Outline of Specification for small Power Station.

- 1. Extent of contract.
- 2. Location.
- 3. Description.
- 4. Excavation.
- 5. Masonry work:
 - A. Foundation walls.
 - B. Brick walls.
 - C. Cut stone.
 - D. Mortar.
 - E. Cement:
 - (a) Kind.
 - (b) Delivery.
 - (c) Testing.
 - (d) Qualities—weight, time of setting, fineness, strength.
 - F. Sand.
 - G. Crushed stone.
 - H. Concrete.

- I.* Placing concrete.
- J.* Stack.
- K.* Machinery foundations.
- L.* Plastering.

6. Roof:

- A.* General.
- B.* Boiler room.
- C.* Engine room.
- D.* Laying tile.
- E.* Tile.
- F.* Gutter and down spouts.

7. General work.

8. Carpenter work.

- A.* Floor of the engine room.
 - (*a*) Joists.
 - (*b*) Floor.
 - (*c*) Stairway.
- B.* Ceiling of engine room.
 - (*a*) Ceiling joists.
 - (*b*) Ceiling.
- C.* Roof.
 - (*a*) Trusses.
 - (*b*) Rafters.
 - (*c*) Roofing.
 - (*d*) Gutters.
- D.* Inside work.
 - (*a*) Doors.
 - (*b*) Windows.
 - (*c*) Trimmings.
 - (*d*) Wainscotting.
 - (*e*) Finishing.
 - (*f*) Lumber.
 - (*g*) Bridging.

9. Painting.

- A.* Paint.

10. Cleaning building.

11. Payments.

§ 3. Outline Specifications for Bridge Substructure.

- 1. Description of work, or extent of contract.
- 2. Plans and drawings.
- 3. Grading, embankments and roadways.
- 4. Foundations.
 - A.* Excavation—Depth and size.
 - B.* Sheet piling, coffer dam or caisson.
 - C.* Pumping and draining.

D. Masonry footings.

Concrete.

E. Piles.

(a) Size.

(b) Driving.

(c) Sawing.

F. Grillage.

(a) Material.

(b) Drift Pins.

G. Riprap.

5. Materials.

A. Stone or gravel.*B.* Cement.*C.* Sand.*D.* Mortar.*E.* Concrete.

6. Masonry.

A. Class.*B.* Footing stone.*C.* Stretchers.*D.* Headers.*E.* Backing.*F.* Bonding.*G.* Laying.

(a) Joints.

(b) Bedding.

(c) In freezing weather.

H. Cutting.

(a) Face.

(b) Joints.

(c) Draft, batter line and corners.

I. Coping.*J.* Pedestals.*K.* Cut water.*L.* Bridge seats.*M.* Pointing.

7. Construction plant.

§ 4. Outline of Specification for Iron Bridges or Structural Work.

(Only general plans furnished)

1. General description.

General data.

Classification.

Description.

Material.

Head room.

Roadway.
 Foot walks.
 Hand rails.
 Stress in timbers.
 Steel beams.
 Floor girder.
 Stringers.
 Bracket plates.
 Bracing.
 Length of span.

2. Load—dead and live and wind.
3. Proportion of plate.
4. Details of construction and workmanship.
5. Qualities of material.
6. Inspection.
7. Painting.
8. Erection.
9. Acceptance.

§ 5. Outline of Specification for Bridge or Roof Truss.

(Detailed plan furnished.)

1. Description of work.
2. Plans.
3. Quality of material.

Class.

Wrought iron.
 Steel.
 Cast iron.
 Phosphor bronze.

Purpose.

Rivets.
 Pins.
 Punching.
 Plates.
 Shapes.
 Eye bars.

4. Workmanship.

5. Details of construction.

Eye bars.
 Tension members.
 Pin holes.
 Ties and counters.
 Turnbuckles.
 Pins.
 Web plates.
 Rivets.
 Splice plates.
 Flooring and wheel guard.

6. Inspection and tests.
7. Painting.
8. Erection.
9. Acceptance.

§ 6. Outline for Specifications for Stand Tower and Appurtenances.

1. Extent of contract.
2. Location.
3. General description.
4. Laying out work.
5. Foundation.
 - A. Excavation and filling.
6. Foundation masonry and masonry superstructure.
 - (a) Concrete, making and placing.
 - (b) Stone or gravel.
 - (c) Cement.
 - (d) Sand.
 - (e) Mortar.
 - (f) Quality of stone.
 - (g) Rubble stone.
 - (h) Cut stone.
 - (i) Valve chambers, pipe tunnels, etc.
7. Trestle.
 - A. Posts.
 - B. Shoe plate and anchorage.
 - C. Cap and top connection.
8. Balcony.
9. Tank.
 - A. Dimensions.
 - B. Material.
 - (a) Inspection.
 - (b) Size of sheet.
 - C. Shop work.
 - (a) Rivet holes.
 - (b) Corners of sheets.
 - (c) Calking edge.
 - (d) Bending and fitting plates.
 - (e) Joints.
 - (f) Bottom.
 - (g) Connection.
 - (h) Manhole.
 - D. Thickness of sheets, size and spacing rivets.
 - (a) Details.
 - (b) Rivets.
 - (c) Riveting.
 - (d) Calking.

10. Appurtenances:

- A. Rising pipe.
- B. Expansion joint.
- C. Frost pipe.
- D. Base.
- E. Automatic valve.
- F. Overflow pipe.
- G. Ladder or stairway.
- H. Cornice.
- I. Roof.
- J. Trap door.
- K. Finishing:
 - (a) Cleaning.
 - (b) Riveted and inaccessible work.
 - (c) Shop coat.
 - (d) Final work.
 - (e) Paint.
 - (f) Inspection.
 - (g) Application.
- L. Testing.

11. Payments.

§ 7. Outline of Specifications for laying Cast Iron Water Pipe,
Including Setting of Special Castings, Hydrants, Valves, etc.

- 1. Description of work and material to be furnished under the contract.
- 2. Approximate quantities and kinds of work to be done under the contract.
- 3. Plans, profiles and drawings.
- 4. Engineering work, lines, grades, etc.
- 5. Special work.
- 6. Materials: Furnished by whom:
 - A. Where delivered to contractor.
 - B. Distribution.
 - C. Delays in receipt of.
 - D. Breakage and inspection.
 - E. Report of number, size and breakage.
 - F. Responsibility.
- 7. Excavation and trenching:
 - A. Line.
 - B. Size of trench:
 - (a) Depth.
 - (b) Width.
 - C. Grade.
 - D. Disposal of material.
 - E. Removing improved street surfaces.
 - F. Material:
 - (a) Earth.
 - (b) Rock.

- G.* Extra excavation and foundation.
- H.* Bell holes.
- I.* Bracing and shoring.
- J.* Protection of buildings.
- K.* Draining, bailing and pumping.
- L.* Obstructions.
- M.* Limits of amount of work opened.
- N.* Bridging trench for street and side walk travel.
- 8. Back filling:
 - A.* Tamping, puddling, etc.
 - B.* Replacing improved street surfaces.
 - C.* Removing shoring, etc.
 - D.* Repairing injuries to pipes, drains, etc.
 - E.* Removal of surplus material, rubbish, etc.
 - F.* Replacing improper material (in rock excavation).
- 9. Pipe laying:
 - A.* Order of laying, storage of pipe, etc.
 - B.* Foundation.
 - C.* Lowering pipe into trench.
 - D.* Cleaning and protecting pipe.
 - E.* Length of pieces admitted.
 - F.* Cutting pipe.
 - G.* Adjusting spigots uniformly.
 - H.* Wet bell holes.
 - I.* Making joints:
 - (*a*) Thickness of joint.
 - (*b*) Depth of lead in joints.
 - (*c*) Gasket.
 - (*d*) Lead.
 - (*e*) Running joint.
 - (*f*) Calking joint.
 - J.* Straps, and bracing of ends, and bends.
- 10. Setting specials and appurtenances:
 - A.* Specials.
 - B.* Hydrants:
 - (*a*) Hydrant walls.
 - (*b*) Drainage.
 - (*c*) Setting and bracing.
 - C.* Valves.
 - D.* Plugs.
 - E.* Drinking fountains.
 - F.* Disconnecting and reconnecting old services.
- 11. Manholes, hydrant wells, valve boxes, etc.
- 12. Connection of new work to old.
- 13. Omissions.
- 14. Defective work and material.

15. Maintenance, guarantee and insurance.
16. Tests.
17. Measurements.
18. Removal of old pipe, etc.
19. Payments.

§ 8. Outline Specifications for Construction of Sewers.

1. Extent of contract. Description of work and material to be furnished under the contract.
2. Approximate or exact quantities and kinds of work. (Quantities given as basis for comparison.)
3. Plans, profiles and drawings.
4. Engineering work, lines, grades, etc.
5. Special work.
6. Materials—furnished by whom:
 - A. If furnished by city:
 - (a) Where delivered to contractor.
 - (b) Distribution.
 - (c) Delays in receipt of.
 - (d) Breakage and inspection.
 - (e) Report of number, size and breakage.
 - (f) Responsibility.
 - B. If furnished by contractor:
 - (a) Pipe and specials.
 - (b) Tile.
 - (c) Brick.
 - (d) Stone.
 - (e) Cement, mortar and concrete.
 - (f) Iron castings.
 - (g) Lumber.
 - (h) Piling.
7. Excavation and trenching:
 - Line.
 - Preservation of line and grade marks.
 - Depth.
 - Width.
 - Grade.
 - Character of material.
 - Disposal of material.
 - Removing improved street surfaces.
 - Earth.
 - Rock.
 - Protection during blasting.
 - Tunneling.
 - Extra excavation.
 - Bell holes.

- Bracing and shoring.
- Sheet piling.
- Foundations, piling, etc.
- Protection of buildings.
- Draining, bailing and pumping.
- Obstructions.
- Care, protection and repairs of
 - Gas pipe.
 - Water pipe.
 - Drains.
 - Cisterns.
 - Reservoirs.
 - Streets and gutters.
 - Sidewalks.
 - Railroads.
 - Cross walks.
 - Fences.
 - Under drains.
- Limits of amount of work opened.
- Bridging trench for street and sidewalk travel.
- Barriers and lights.

8. Back filling.

- Puddling.
- Tamping, flushing, etc.
- Replacing improved street surfaces.
- Removing shoring, etc.
- Repairing injuries to pipes, drains, etc.
- Cleaning and flushing sewers.
- Use of city water supply.

9. Removal of surplus material, rubbish, etc.

- Replacing improper material.
- Frozen material.

10. Embankment.

11. Pipe sewers.

- Foundation.
- Joints.
- Protecting and keeping sewers clean.
- Removal and rebuilding defective work.

12. Brick sewers.

- Brick laying.
- Foundation.
- Forms.

13. Brick masonry.

14. Stone masonry.

15. Appurtenances.

- A. Flush tanks:
 - (a) Syphon and fixtures.
 - (b) Connecting with water pipe.
 - B. Manholes:
 - (a) Ladders and steps.
 - (b) Foundation.
 - C. Catch basins.
 - D. Outlets.
 - E. Branch sewers and connections.
 - F. Tile drains.
 - G. Iron pipe.
 - H. Special construction with specifications for material and work.
16. Inspection:
- A. Defective material.
 - B. Removal and rebuilding.
17. Extra work.
18. Omissions.
- Condemned, inferior or defective work.
19. Maintenance and guarantee.
20. Tests and requirements.
- Measurements of quantities.
21. Acceptance.

APPENDIX B

SAMPLE CONTRACT AND SPECIFICATIONS FOR
A COMPLETE STRUCTURE

CONTRACT AND SPECIFICATIONS
FOR THE CONSTRUCTION OF
A CONCRETE RESERVOIR AND SUCTION WELL
FOR THE CITY OF MADISON, WISCONSIN

.....

.....

CONSULTING ENGINEERS
MADISON, WISCONSIN

CONTRACT AND SPECIFICATIONS FOR THE CONSTRUCTION OF A CON-
CRETE RESERVOIR AND SUCTION WELL FOR
THE CITY OF MADISON, WISCONSIN.

EXHIBIT A

NOTICE TO CONTRACTORS

Sealed bids for furnishing all labor and material for the construction of a reinforced concrete reservoir and a reinforced concrete suction well for the improvement of the water works system of the city of Madison, Wisconsin, will be received at the office of the city clerk in the city hall until two o'clock p. m., Wednesday, July 12, 1916, at which time the bids will be opened and publicly read, after which the bids will be considered and the award made as early as practicable.

A certified check on a reputable National or State Bank or a bank draft for five hundred dollars (\$500) made payable without reserve to the treasurer of the city of Madison, Wisconsin, must accompany each bid.

Instructions to bidders and blank forms of proposals may be obtained and plans and specifications may be seen at the office of the superintendent of the water works, Madison, Wisconsin, or at the office of
..... State Street, Madison, Wisconsin.

———, City Clerk.

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EXHIBIT B

GENERAL CONDITIONS AND INSTRUCTIONS TO BIDDERS

1. Sealed bids for furnishing all labor and all materials for the construction of a reinforced concrete reservoir and a reinforced concrete suction well for the city of Madison, Wisconsin, endorsed with the name of the bidder and with the title of the work upon which the bid is made will be received at the office of the city clerk in the city hall until two o'clock p. m., Wednesday, July 12, 1916, at which time the bids will be opened and publicly read, after which the bids will be considered and the award made as early as practicable.

2. The work will include approximately the following items:

A. Reinforced Concrete Reservoir

Excavation	2,500 cu. yds.
Concrete	1,430 cu. yds.
Reinforcing Rods	112,950 pounds
15" Vitrified Gutter Pipe.....	125 feet
8" Vitrified Sewer Pipe.....	40 feet
Drain Connections.....	2 feet
Ventilating Manholes in Roof.....	7
2 Coats Cement Wash.....	46,830 sq. yds.
30" Class B. C. I. Water Pipe.....	12 feet
20" Class B. C. I. Water Pipe.....	84 feet
20" C. I. 90° Elbow	1

B. Reinforced Concrete Suction Well

Excavation	360 cu. yds.
Concrete	95 cu. yds.
Reinforcing Rods	4,416 pounds
Steel Manhole Frame & Cover.....	1
30" Class B C. I. Water Pipe (1 length).....	4 feet
24" Class B C. I. Water Pipe—3 lengths, each.....	4 feet

3. No proposal can be withdrawn after the time for receiving bids has expired.

4. The price must be written in the bid and also stated in figures. In any event, the prices must be so distinctly expressed that there can be no doubt as to the meaning of the same. Illegible figures will invalidate the bid.

5. Bidders must secure their information as to local conditions of trade, character of soil, probable amount of water, rock, etc., from personal inquiry on the ground.

6. Work must be begun promptly after the award of the contract and within such time as stated by the successful bidder, and be completed by the time named by said bidder.

7. The right is reserved to reject any or all bids, to waive any informality in any bid received, to accept any bid considered advantageous to the City of Madison, and also to disregard any failing or irresponsible bidder or contractor, known as such.

8. Each bid for each item must include the performance of all work and all the material in accordance with the general contract and specifications for the work and material included under the items on which a bid is submitted.

9. Bidders are notified that the price bid must include everything as described in the specifications under each item. No extras of any kind will be allowed unless ordered in writing by the consulting engineers and endorsed by the superintendent of the water works.

10. A bond satisfactory to the common council of the city of Madison in the sum of fifty per cent. (50%) of the contract price will be required with each contract.

11. The bidder must, if desired, satisfy the mayor of his practical and financial ability to perform the work for which he bids.

12. A certified check, on a reputable National or State Bank or a bank draft made payable without reserve to the city treasurer of Madison, Wisconsin, for five hundred dollars (\$500), must accompany each bid. Such certified check shall be deposited as a guarantee that the bidder, if successful, will enter into the contract and furnish a satisfactory bond for the construction of the work, and the furnishing of the material in accordance with the plans, specifications and his proposal, within fourteen (14) days after notice to the award of said contract to him, and if he fails or refuses so to do, said check shall be forfeited to the city of Madison as liquidated damages for such failure. The check of the successful bidder will be returned to him upon his entering into a contract, furnishing a satisfactory bond, and when he shall have actually performed at least five hundred dollars worth of work under this contract. Checks of unsuccessful bidders will be returned when the contract is signed or when the bids are rejected.

13. All bids must be self-explanatory. No opportunity will be offered for oral explanation except as the party of the first part desires more full explanation of particular or peculiar devices.

14. Payment for this work will be made in cash, and in accordance with the contract and specifications.

15. Plans, specifications, form of contract, and proposal may be seen at the office of the superintendent of the water works, Madison, Wisconsin, or at the office of the undersigned, — State Street, Madison, Wisconsin.

Bidders are invited to be present at the opening of bids.

....., Consulting Engineers.

EXHIBIT C

FORM OF PROPOSAL

To the Mayor and City Council, Madison, Wisconsin:

GENTLEMEN: The undersigned declare.. that ha.. carefully examined the plans, general form of contract, specifications, and the location of the work, and hereby agree to furnish all material and do all work, and complete in a good and workmanlike manner and in accordance with the plans and under the conditions named in the general form of contract and the specifications therefor, the following work at the prices named:

1. For doing all work and furnishing all materials to construct the reinforced concrete reservoir in accordance with plans and specifications, but not including the hauling of the surplus material excavated, and not including the timber floor under the concrete floor of the reservoir, the lump sum of dollars (\$.....).

2. For furnishing all labor and material to construct the timber floor under the concrete floor of the reservoir, in case it is ordered constructed by the engineers, per thousand F. B. M. in place dollars (\$.....).

3. For additions or deductions in the yardage of concrete, per cubic yard dollars (\$.....).

4. For additions or deductions in the reinforcing rods, per pound cents (.....c).

5. For additions or deductions in the excavation, per cubic yard cents (.....c).

6. For furnishing all labor and material to construct the reinforced concrete suction well in accordance with the plans and specifications, not including the hauling of the excavated material and not including the construction of a timber floor under the concrete floor, the lump sum of dollars (\$.....).

7. For hauling and depositing the surplus material excavated from the site to such points as the engineers may designate, at the following prices per cubic yard, depending upon the length of haul:

<i>Average Haul</i>	<i>Price per cu. Yard.</i>
Up to 1320 Feet.....	\$.....
1320 to 2640 Feet.....	\$.....
2640 to 3960 Feet.....	\$.....
3960 to 5280 Feet.....	\$.....

8. For furnishing all labor and material to construct the timber floor under the bottom of the suction well in case it is ordered constructed by the engineers, the lump sum of dollars (\$.....).

9. For all labor and material to increase the depth of the suction well from that shown on the plans up to five (5) feet increase in depth, per foot of increase in depth, the lump sum of (\$.....).

10. For all extra work ordered by the consulting engineers and not included under any of the above heads, cost plus per cent. (.....%).

..... further agree to sign the contract, furnish a satisfactory bond of the amount required, and begin the work within days after receiving notice of the award to, and to complete said work within months after receiving notice of the award.

..... enclose herewith a certified check (or bank draft) for five hundred dollars (\$500) made payable without reserve to the city treasurer of Madison, Wisconsin, which agree.. to forfeit if the contract is awarded to and fail to enter into the same in accordance with the proposed form of contract, and within fourteen (14) days after notice of the award to

Respectfully submitted,

.....

Contractor.

Address:

.....

.....

GENERAL CONTRACT

FOR

REINFORCED CONCRETE RESERVOIR AND SUCTION WELL
CONTRACT EXECUTED IN TRIPLICATE

This Agreement made and concluded this day of, A. D., ..., by and between, county of, state of, party of the first part, and of the city of, county of and state of, party of the second part.

Witnesseth: That for and in consideration of the payments and agreements hereinafter mentioned to be made and performed by said party of the first part, and under the penalty expressed in a bond bearing even date herewith, the said party (or parties) of the second part agrees with the said party of the first part, at his (or their) own cost and expense, to do all the work and furnish all material called for by this agreement, in the manner and under the conditions hereinafter specified.

Interpretation of Phrases.—Whenever the word “city” or the expression “party of the first part,” or “first party,” are used in this contract it shall be understood as referring to the city of Madison, Wis. Whenever the word “contractor,” or the expression “party of the second part,” or “second party” are used it shall be understood to mean the person, persons, co-partnership or corporation who has agreed to perform the work embraced in this contract or to his or their legal representatives.

Whenever the word “engineer” is used in this contract it shall be understood as referring to the consulting engineer of the party of the first part, or such other engineer, superintendent or inspector as may be authorized by said first party to act in any particular. Whenever the words “directed,” “required,” “permitted,” “designated,” “considered necessary,” “prescribed,” or words of like import are used, it shall be understood that the direction, requirement, permission, order, designation or prescription, etc., of the engineer is intended; and similarly, the words approval, acceptable, satisfactory, or words of like import shall mean approved by or acceptable or satisfactory to the engineer.

Whenever in the specifications or drawings accompanying this agreement, the terms or descriptions of various qualities relative to “finish,” “workmanship,” or other qualities of similar kind which cannot from their nature be specifically and clearly described and specified but are necessarily described in general terms to be “satisfactory,” “first class,” “workmanlike,” or in other terms the fulfillment of which must depend on individual judgment, then, in all such cases, any question of the fulfillment of said specifications shall be decided by the consulting engineer, and said work shall be done in accordance with his interpretations of the meaning of the words, terms or clauses defining the character of the work.

Quantities and Measurements.—No extra or customary measurements of any kind will be allowed, but the actual length, the area, the solid contents, the number and weight only shall be considered, unless otherwise specifically provided.

Superintendence and Inspection.—It is agreed by the party of the second part that the party of the first part shall be, and hereby is authorized to appoint from time to time such engineer, superintendent or inspector as the said first party may deem proper, to inspect the material to be furnished and the work to be done under this agreement and in accordance with the specifications therefor. The contractor shall furnish all reasonable aid and assistance required by the engineer, superintendent or inspector for the proper inspection and examination of the work and all parts of the same. The contractor shall regard and obey the directions and instructions of any engineer, superintendent or inspector so appointed when the same are consistent with the obligations of this agreement and of the specification attached hereto, or said contractor shall immediately appeal to the consulting engineer for his decision, and shall respect such decision when so rendered.

Right of Entry.—The party of the first part reserves the right to enter the property or location on which the works herein contracted for are to be constructed or installed by such agent or agents as it may elect for the purpose of constructing or installing such collateral works as said first party may desire. Such collateral works will be constructed or installed with as little hindrance or interference as possible with the party of the second part. The party of the second part hereby agrees not to interfere with or prevent the performance of such collateral work by the agent or agents of the party of the first part, or to claim any extra compensation or damages by delays or hindrances which may be caused by the construction or installation of such collateral work.

Changes, Alterations and Extra Work.—The said party of the second part further agrees that the said first party may make such alterations as said party may see fit in the line, grade, form, dimensions, plan or material of the work herein contemplated, or any part thereof, either before or after the beginning of the construction.

If such alterations diminish the quantity of the work to be done, they shall not constitute a claim for damages or anticipated profits on the work that may be dispensed with. If they increase the amount of work, such increase shall be paid for according to the quantity actually done, and at the prices established for such work under this contract; provided, however, that if said first party shall make such changes or alterations as shall make useless any work already done or material already furnished or used in said work, that said first party shall recompense said party of the second part for any material or labor so used and for any actual loss occasioned by such change due to actual expenses incurred in preparation for the work as originally planned.

No work shall be regarded as extra work unless it is ordered in writing by the engineer and endorsed by superintendent of water works, and with the agreed price for the same specified in said order, provided said price is not

otherwise determined by this contract. All claims for extra work shall be made to said first party before said extra work is started and a statement of the cost of the same shall be made within sixty (60) days after the completion of said extra work.

Discrepancies and Omissions.—It is further agreed that it is the intent of this contract that all work must be done and all material must be furnished in accordance with the best practice, and in the event of any discrepancies between the plans and specifications, or otherwise, or in the event of any doubt as to the meaning of any portion of the contract, specifications or plans, the engineer shall define which is intended to apply to the work, and the contractor shall be bound by such decision.

Any work or material not herein specified but which may be fairly implied as included in the contract, of which the engineer shall be the judge, shall be done or furnished by the contractor without extra charge.

Estimated Quantities.—This agreement, including the specifications, plans and estimate, is intended to show clearly all work to be done and material to be furnished hereunder. The estimated quantities of the various classes of work to be done and material to be furnished under this contract are approximate and are to be used only as a basis for estimating the probable cost of the work and for comparing the proposals offered for the work. It is understood and agreed that the actual amount of work to be done and material to be furnished under this contract may differ somewhat from these estimates, and that the basis for payment under this contract shall be the actual amount of such work done and the material furnished.

The contractor agrees that he will make no claim for damages, anticipated profits or otherwise on account of any differences which may be found between the quantities of work actually done, the material actually furnished under this contract and the estimated quantities contained in this agreement.

Engineer's Authority: Supervision and Direction of Work.—It is mutually agreed between the parties to this contract that the engineer shall supervise and direct all work included herein. To prevent disputes and to discourage litigation, it is further agreed by and between the parties to this contract that if it cannot be otherwise agreed, the engineer shall in all cases determine the amount of the quantities of the several kinds of work which is to be paid for under this contract, and he shall determine all questions in relation to said work and the construction thereof, and he shall in all cases decide every question which may arise relative to the execution of this contract on the part of said contractor, and his estimate and findings shall be the conditions precedent to the right of the parties hereto to arbitration or to any action on the contract and to any rights of the contractor to receive any money under this contract. The engineer shall within a reasonable time render a decision on all claims of the parties hereto and on all questions which may arise relative to the execution of the work or the interpretation of the contract, specifications and plans.

Lines and Grades.—All lines and grades shall be furnished by the engineer but the contractor shall provide stakes and such ordinary labor as may reasonably be required by the engineer to assist him in such work. When-

ever necessary, work shall be suspended to permit of this work, but such suspension will be as brief as practicable and the contractor shall be allowed no extra compensation therefor. The contractor shall give the engineer ample notice of the time and place where lines and grades will be needed. All stakes, marks, etc., shall be carefully preserved by the contractor and in case of their destruction or removal by him or his employees, such stakes, marks, etc., shall be carefully preserved by the contractor and in case of their destruction or removal by him or his employees, such stakes, marks, etc., shall be replaced by the engineer at the contractor's expense.

Emergencies.—Whenever in the opinion of the engineer the contractor has not taken sufficient precaution for the safety of the public or the protection of the work to be constructed under this contract, or of adjacent structures or property which may be injured by processes of construction on account of such neglect, and whenever in the opinion of said engineer an emergency shall arise and immediate action shall be considered necessary in order to protect public or private, personal or property interests, and the contractor shall fail to immediately provide the necessary protection after notice by said engineer or without such notice when the emergency makes such a course necessary, the said engineer may provide suitable protection to said interests by causing such work to be done and material to be furnished and placed as shall furnish such protection as said engineer may consider necessary and adequate.

The cost and expense of such work and material so furnished shall be borne by said contractor, and if the same shall not be paid on presentation of the bills therefor, then said costs shall be deducted from any accounts due or which may become due said contractor.

The failure of the engineer to order the performance of said emergency work shall in no way relieve the contractor from any damages that may result by the omission of said emergency work or protection.

Preliminary Approval.—No engineer, superintendent or inspector shall have any power to waive the obligations of this contract for the furnishing by the contractor of good material and of his performing good work as herein described, and in full accordance with the plans and specifications. No failure or omission of any engineer, superintendent or inspector to condemn any defective work or material shall release the contractor from the obligations to at once tear out, remove and properly replace the same at any time upon the discovery of said defective work or material.

Right of Engineer to Modify Methods and Equipment.—If at any time the methods or equipment used by the contractor are found to be unsafe or inadequate for securing the safety of the workmen or other persons who may be endangered thereby, or to secure the quality of work or the rate of progress required under this contract, the engineer may order the contractor to increase their safety or improve their character and efficiency, and the contractor shall comply with such order.

If at any time the working force of the contractor is inadequate for securing the progress herein specified the contractor shall, if so ordered, increase his force or equipment, or both, to such an extent as to give reasonable assurance of compliance with the schedule of progress.

The failure of the engineer to make such demands shall not relieve the contractor of his obligations to secure the safety of his men, the quality of the work, and the rate of progress required by his contract.

Right to Retain Imperfect Work.—If any part or portion of the work done or material furnished under this contract shall prove defective and not in accordance with the plans and specifications, and if the imperfections in the same shall not be of sufficient magnitude or importance to warrant removal, or if the removal of such work will create conditions which are dangerous or undesirable, the engineer shall have the right and authority to retain such work, but shall make such deductions in the final payment therefor as may be just and reasonable.

Arbitration—The engineer shall, within a reasonable time, decide all questions or claims of either party to this contract and all matters relating to the execution and progress of the work or the interpretation of the plans, specifications and contract.

It is further agreed that in case the engineer renders any decision or gives any directions which in the opinion of either party hereto is not in accordance with the meaning and intent of this contract, either party may file with said engineer his written objection to the decision or directions so rendered and by such action may reverse the right to submit the question so raised to arbitration as hereinafter provided. There shall nevertheless be no delay in the execution of the work, and the decision or directions of the engineer so rendered shall be promptly carried out, and any claims arising therefrom shall be thereafter adjusted by arbitration.

It is further agreed by both parties hereto that all questions subject to arbitration or adjustment shall be raised and filed with the engineer prior to the execution of the directions of the engineer and that all questions of difference must be raised prior to the final payment on the contract, and that both parties shall lose all right to raise further objection to the engineer's decisions after the final payment has been made.

The general procedure shall conform to the laws of the state if necessary, and the decision of the arbiter may be filed in court to carry it into effect.

If the engineer fails to make a decision within a reasonable time, an appeal to arbitration may be taken, as if his decision had been rendered against the party appealing. In such cases and in case of an appeal from the engineer's decision, the demand for arbitration shall be filed with him in writing within ten (10) days thereafter; and in no case later than the time of final payment.

The parties may agree upon one arbiter, otherwise there shall be three; one named in writing by each party, and the third chosen by the two arbiters so selected; or if the arbiters fail to elect a third within ten days, he shall be chosen by the presiding official of the Bar Association of Dane county. Should the party demanding arbitration fail to name an arbiter within ten days of the demand, his right to arbitrate shall lapse, and the decision of the engineer shall be final and binding on him. Should the other party fail to choose an arbiter within ten days, the engineer shall appoint such arbiter. Should either party refuse or neglect to supply the arbiter with any papers

or information demanded in writing, the arbiters are empowered by both parties to take *ex parte* proceedings.

The arbiters shall act with promptness. The decision of any two shall be binding on both parties to the contract. The decision of the arbiters upon any question subject to arbitration under this contract shall be a condition precedent to any right of legal action.

The arbiters, if they deem the case demands it, are authorized to award the party whose contention is sustained, such sums as they deem proper for the time, expense and trouble incident to the appeal and if the appeal was taken without reasonable cause, damages for any delay occasioned. The arbiters shall fix their own compensation, unless otherwise provided by agreement, and shall assess the cost and charges of the arbitration upon either or both parties. The award of the arbiters must be made in writing, and if in writing shall not be open to objection on account of the form of the proceedings or award.

Prices and Payments. Estimates and Payments.—In order to enable the contractor to prosecute the work to advantage, an estimate in writing will be made by the engineer once a month of the amount of work done and material furnished (and material delivered on the ground and to be used in the completed work), and of the value thereof according to the terms of the contract. The first estimate shall be of the amount or quantity in value of the work done since the party of the second part commenced the performance of this contract, and every subsequent estimate except the final one shall be the amount or quantity and value of work done since the last preceding estimate was made. No such estimate of amount or quantity shall be required to be made by strict measurement or with exactions but may be approximate only.

Upon the approval of said estimate by the consulting engineer, the party of the first part will pay to the party of the second part 85 per cent. of such estimated value, and whenever said contract shall be duly completed, in accordance with the terms herein contained, and when said work and material shall be accepted by the consulting engineer, for said party of the first part, a careful and detailed estimate shall be made of the value of all work and material furnished under said contract, and the amount due on said work shall be paid to said party of the second part, provided however that it is not considered necessary by said first party to retain a certain proportion of same as elsewhere provided for protection against claims for labor and material, for damages, for royalties or otherwise, and excepting also any amount retained as guarantee for the maintenance of the work or material furnished under this contract or for forfeiture.

Delayed Payment.—In case any payment to the contractor on any estimate is delayed by the party of the first part beyond the time provided herein, said first party shall pay the contractor interest on the amount due at the rate of five (5) per cent. per annum for the period of such delay. The term for which said interest shall be paid shall, in the case of progress estimates, date from the 10th day after the date of said estimate, to the date of payment of the estimate,—and in case of the final estimate from thirty days after the filing of the certificate of completion and acceptance to the date of final payment of the final estimate.

If interest shall become due on any progress estimate, the amount thereof shall be added to the succeeding estimate; and if interest shall become due on the final estimate, it shall be added to such final estimate and paid therewith. The contractor shall not be entitled to interest on any sum or sums which by the terms of this contract the party of the first part may be authorized to retain. It is hereby agreed that such interest payments, if any, are to be in lieu of any claims of the contractor for alleged damages for breach of contract or otherwise on account of delayed payments.

Extra Work.—If during the performance of this contract the engineer shall order in writing other work done or materials furnished which in his opinion cannot be classified under the unit prices of this contract, the contractor shall do and perform such work and furnish such material and shall be paid therefor the actual cost thereof plus per cent in addition thereto. The actual cost is hereby defined to include the cost of all labor and materials necessary for the performance of the extra work, including any extra expenses incurred directly on account thereof, also the wages of foremen and the expenses attached to contractor's liability insurance covering the labor so employed.

No allowance shall be made for overhead charges, general superintendence, general expenses, contingencies, or use and depreciation of the construction plant; neither shall said charges include the maintenance of the contractor's camp or office, unless such camp or office be maintained primarily on account of such extra work.

Price for Work.—In consideration of the furnishing of the material and the completion of all work by the said party of the second part, and on the completion of all work and of the delivery of all material embraced in this contract in full conformity with the specifications and stipulations herein contained, the party of the first part agrees to pay the said second party the prices set forth in the proposal hereto attached, marked "Exhibit C" which is hereby made a part of this contract. And the said party of the second part hereby agrees to receive such prices in full for furnishing all material and all labor required for the aforesaid work, also for all expense incurred by him and for well and truly performing the same and the whole thereof in the manner and according to the specifications and requirements of the engineer.

Contractor's Responsibility.—*Personal attention of the contractor.* The contractor shall give personal attention to the faithful prosecution and completion of this work and shall be present either in person or by duly authorized representative on the site of the work continually during its progress. He shall maintain an office on or adjacent to the site of the work.

Contractor's Address.—Both the address given in the proposal upon which this contract is based and the contractor's office at or near the site of the work are hereby designated as places to either of which notices, letters or communications to the contractor may be mailed or delivered. The delivery at either of the above named places of any such notices, letters or other communications for the party of the first part to the contractor shall be deemed sufficient services thereof upon the contractor, and date of said services shall be the date of such delivery.

Contractor's Agent.—The contractor during his absence from the work shall keep a competent superintendent or foreman upon the work, fully authorized to act for him in his absence, and to receive such orders as may be given for the proper continuance of the work. Notice of any imperfections in the work or material furnished to any foreman or agent in charge of any portion of the same, in the absence of the contractor, shall be considered as notice to the contractor.

Observance of Laws and Ordinances.—The party of the second part shall be subject to all laws and ordinances of the city of Madison of Dane county, Wisconsin, within which this agreement is to be fulfilled, and said contractor shall be entitled to no exemption therefrom on account of this contract.

Protection Against Negligence and Damages.—Should any work be done or material furnished or placed on public streets or ways or in any other place where protection is necessary, the contractor shall at all times and especially during the night, put up and maintain such barriers and red lights and take such other needful precautions as may be necessary to effectually prevent the occurrence of any accidents in consequence of the work being done or material being deposited in such places, and the contractor shall be liable for all damages occasioned in this way by reason of his act or neglect or that of any sub-contractor or any agent, employee or workman; and the said contractor shall save and keep harmless the said first party from all suits or demands for damages alleged to have occurred to persons or property by reason of said work or of so placing said material or from said act or negligence.

The said party of the second part further agrees during the performance of the work to take all necessary precautions and to place proper guards for the prevention of accidents and put up at night suitable and sufficient light, and will indemnify and save harmless the said parties of the first part from all damages and costs to which they may be put by reason of injury to persons or property, resulting from negligence or carelessness in the performance of the work or in guarding the same, or from any improper material used in its construction or by or on account of act or omission of the said party of the second part or his agents or employees; and the said party of the second part hereby further agrees that the whole or so much of the money due under or by virtue of the agreement as shall be considered necessary by the consulting engineer shall or may be retained by the party of the first part until all suits or claims for damages, as aforesaid, have been settled and satisfactory evidence to that effect furnished the said consulting engineer.

The said contractors shall take proper means to protect the adjacent or adjoining property or properties in any way encountered or which might be injured by any process of construction, to be undertaken under this agreement, and he shall be liable for any or all claims for damages on account of his failure to fully protect all property injured during or on account of such construction.

Protection Against Claims for Labor and Material.—The said party of the second part agrees that he will indemnify and save harmless the party of the first part from all claims against said first party for material furnished or work done under this contract, and it is further agreed by the party of the

second part that said second party shall if so desired furnish the said first party satisfactory evidence that all persons who have done work or furnished material under this agreement have been duly paid for such work or material, and in case such evidence is demanded by and not furnished to the aforesaid first party, such amount as may in the opinion of the said first party be necessary to meet the claims of the persons aforementioned, may be retained from the money due said party of the second part under this agreement, until satisfactory evidence is furnished that all liabilities have been fully discharged.

Protection Against Royalties or Patented Inventions.—The contractor shall protect and save harmless the party of the first part from all and every demand for damages, royalties or fees on any patented invention used by him in connection with the work done or material furnished under this contract unless the article or invention is clearly and specifically required by this contract; and it shall be the duty of the contractor, if so demanded by the party of the first part, to furnish said first party with a proper legal release or indemnity from and against all such claims, and any or all payments may be withheld from said contractor until said release is furnished if the party of the first part so elects.

If any patented material, machinery, appliance or invention is clearly specified in this contract, then and in that event the cost of procuring the rights of use and the legal release or indemnity shall be borne and paid by the party of the first part.

Assignment and Subletting.—The said contractor further agrees that he will give his personal attention to the fulfillment of the agreement and that he will not sublet the aforesaid work or the furnishing of the aforesaid material but will keep the same under his personal control, and that he will not assign by power of attorney or otherwise any portion of said contract unless by and with the previous consent of the first party.

Abandonment.—In case the contractor shall abandon the work and fail or refuse to commence it again within ten (10) days after notification from the first party, or if he shall fail to comply with the orders of the engineer or with this agreement or with the specifications hereto attached, then and in that case the sureties on the bond shall be notified and directed to complete the same. In case the sureties fail to comply with the notice, the first party may, within ten (10) days after serving such notice, carry on the work at the expense of the contractor and the sureties.

Time and Order of Completion.—It is the meaning and intent of this contract, unless otherwise hereafter specifically provided, that the contractor shall be allowed to prosecute his work at such times and seasons, in such order of precedence, and in such manner as shall be most conducive to economy of construction, provided, however, that the order and the time of prosecution shall be such that the work shall be completed as a whole and in part in full accordance with the specifications and within the time of completion hereafter designated; provided also that when the first party is having other work done, either by contract or by its own force, the engineer may direct the time and manner of constructing the work done under this contract, so that con-

flict will be avoided and the various works being done for the party of the first part shall be harmonized. The engineer will arrange, for all such work, so as to avoid so far as practicable all unnecessary inconvenience and expense to all parties concerned.

The party of the second part further agrees that he will commence the work within days after the execution of this contract and will progress therewith so that by the day of 19.., the work shall be completed in accordance with this agreement.

Conduct of the Work. Keeping of Plans and Specifications Accessible.—The contractor shall be furnished with two copies of all plans, profiles and specifications and shall keep one copy of the same constantly accessible on the work.

Character of Workmen.—The said party of the second part agrees to employ only orderly, competent and skillful men to do the work; and that whenever the engineer shall inform him in writing that any man or men on the work are in his opinion incompetent, unfaithful or disorderly, such man or men shall be discharged from the work and shall not again be employed on the same without the engineer's written consent.

Losses and Damages.—All loss or damage arising out of the nature of the work to be done or from the action of the elements or from any unforeseen circumstances in the prosecution of the same, or from unusual obstructions or difficulties which may be encountered in the prosecution of the work shall be sustained and borne by the contractor at his own cost and expense.

Protection of Finished or Partially Finished Work.—The contractor shall take all necessary precautions to protect all work done or material furnished under this agreement from injury by action of the elements or by the process of construction; he shall also take proper means to protect adjacent or adjoining property in any way encountered or which might be injured by the process of construction to be taken under this agreement.

The contractor shall properly guard and protect all finished or partially finished work, and shall be responsible for the same until the entire contract is completed and accepted by the engineers. Estimate of partial payment on work so completed shall not release the said contractor from such responsibility but he shall turn over the entire work in full accordance with this contract before final payment shall be made.

Hindrances and Delays.—No charge shall be made by the contractor for hindrances or delays from any cause (except where the work is stopped by order of the party of the first part) during the progress of any portion of the work embraced in this contract; but such delays may entitle him to an extension of time, allowed for completing the work, sufficient to compensate for the detention, the amount of the detention to be determined by the engineer, provided the contractor shall give the engineer immediate notice in writing of the cause of such detention. In case said work shall be stopped by the act of the party of the first part, then such expense as in the judgment of the engineer is caused by such stopping of said work, other than the actual cost of carrying on the contract, shall be paid by the party of the first part to the party of the second part.

Defects and Their Remedies.—It is further agreed that if the work or any part thereof, or any material brought on the ground for use in the work or selected for the same, shall be deemed by the engineer as unsuitable or not in conformity with the specifications, the contractor shall forthwith remove such material and rebuild or otherwise remedy such work so that it shall be in full accordance with this contract.

Construction Plant.—The contractor shall provide all labor, tools, machinery and material necessary in the prosecution and completion of this contract where it is not otherwise specifically provided that the party of the first part shall furnish the same, and it is also understood that the party of the first part shall not be held responsible for the care or protection of any material, tools or machinery or any part of the work until it is finally completed and accepted.

Police and Sanitary Regulations. Sanitation.—Necessary sanitary conveniences for the use of laborers on the work, properly secluded from public observation, shall be constructed and maintained by the contractor in such manner and at such points as shall be approved by the engineer, and their use shall be strictly enforced.

Contractor's Buildings.—The building structures for tools and material or other forms of protection will be permitted only at such places as the engineer shall direct, and the sanitary condition of the grounds in or about such structure shall at all times be maintained in a manner satisfactory to the engineer.

Bond.—It is further agreed by the parties to this contract that this contract shall be executed in triplicate, one copy being retained by the party of the first part, one to be delivered to the contractor, and one to the consulting engineer. The party of the second part agrees to execute a bond for the sum of dollars (\$.....) for the satisfactory performance of the work in the form provided for this purpose, and it is agreed that this contract shall be void until such bond is furnished and approved by common council of Madison.

IN WITNESS WHEREOF the parties to these presents have hereunto set their hands and seals the year and day first above given.

..... (SEAL).
 (SEAL).
 (SEAL).
 (SEAL).

EXHIBIT D

SPECIFICATIONS FOR

THE CONSTRUCTION OF A CONCRETE RESERVOIR AND SUCTION WELL FOR THE CITY OF MADISON, WISCONSIN

1. *Extent of Contract.*—These specifications include the furnishing of all labor and material, except where otherwise specifically stated, necessary to construct and complete the reinforced concrete reservoir and reinforced concrete suction well, all to the forms and dimensions shown on the plans for said work accompanying these specifications and numbered A—2273, A—2274, A—2282 and A—2275, which plans are hereby made a part hereof. This work shall include:

a. The furnishing of all labor, tools and material necessary to excavate and properly prepare the foundations for the structures, properly backfilling around the structures and disposing of excess excavated material in accordance with the plans and specifications.

b. The furnishing of all labor, material and equipment for mixing and placing all concrete in the floor, walls, columns and roof as hereinafter specified.

c. The furnishing and placing of all steel bars for reinforcing the concrete as shown on the plans and in accordance with these specifications.

d. The furnishing and placing of manholes and covers as shown on the plans.

e. The furnishing and placing of vitrified gutter and connection of same with the storm water sewer as shown on the plans.

f. The furnishing of all labor, tools and construction equipment necessary to do all the work included in these specifications.

g. The city of Madison will furnish all water required for mixing and placing the concrete and all water required in any or all boilers used by the contractor in prosecuting the work included under these specifications at a price of six cents (6c) per hundred cubic feet to the contractor at a city hydrant or city tap nearest to the location selected by the contractor for his mixing plant. The water will be that of the city water system and will be supplied at the pressure ordinarily prevailing at this hydrant or tap under the usual operating conditions. The city will furnish free of cost to the contractor not more than two (2) meters for measuring the water and the contractor shall be held responsible for any damages that may occur to said meters while used on this work.

The contractor shall at his own cost and expense furnish the necessary reducers, valves and pipes required to regulate and convey the water from the hydrant or tap to the points where the water will be used. All pipes used in conveying water from the hydrant shall be so placed as not to interfere with traffic on public thoroughfares across which said pipe may be carried.

The contractor shall be held responsible for any damage to the hydrant or tap caused by his laborers or agents during the time said connection is made with the hydrant or tap. The method of connecting to the hydrant shall be subject to the approval of the superintendent of the water works of the city of Madison, and in such manner as not to interfere with the connection of a fire hose to at least one nozzle of said hydrant.

The contractor shall provide a suitable storage room wherein to house a sufficient quantity of cement to prosecute the construction in a good and workmanlike manner. Said storage room shall be constructed so that the cement will be kept dry and free from danger of injury in any way.

2. *Estimated Quantities.*—The following are the estimated quantities of work and material included in this contract:

RESERVOIR

Excavation	2,500 cu. yds.
Concrete—reinforced	1,430 cu. yds.
Steel Reinforcing Bars and Ladder.....	112,950 pounds
Manholes 24 in. C. I.....	7
Wall Flange 30 in. Pipe.....	1
Wall Flange 20 in. Pipe.....	1
30 in. Pipe.....	12 lin. feet
20 in. Pipe.....	84 lin. feet
20 in. Pipe Elbow.....	1
Vitrified Pipe Gutter.....	125 lin. feet
Vitrified Pipe (8 in. Connection to Sewer).....	40 lin. feet
2 Coats Cement Wash inside.....	46,830 sq. yards

SUCTION WELL

Excavation	360 cu. yds.
Concrete—reinforced	95 cu. yds.
Steel Reinforcing Bars.....	4,416 pounds
24 in. Pipe—Flanged—4 ft. lengths.....	3 lengths
30 in. Pipe—4 ft. length, flanged on one end, bell on one end	1 length
Manhole, Structural Steel built up.....	1

3. *Description.*—(a) *Reservoir.*—This structure is to be used for the storage reservoir for the water supply of the city of Madison, Wisconsin, and is to be located adjacent to the present reservoir on East Dayton street between Blair and Blount streets, facing East Dayton street, covering portions of lots 12, 13 and 14 of block 120, according to the plat of this locality.

(b) *Suction Well.*—This structure is to be used for the suction of new and additional high service pumping machinery and is to be located on the block now occupied by the water works pumping station between the station building and Gorham street.

4. *Excavation.*—The excavation for all structures and foundations shall be carried to the grades indicated on the plans and to lines not more than two (2) feet from the neat exterior lines of the structure.

All material excavated, except such as is needed for backfilling, shall remain the property of the city and shall be hauled and deposited at such points as may be designated by the engineers at the price named in the proposal.

5. *Concrete Work*.—(a) The concrete shall consist of one (1) part of Portland cement, two (2) parts of fine aggregate, and four (4) parts of coarse aggregate. The proportions of the aggregate shall be based on the volumetric measurements in the following manner. One (1) bag of cement, approximately ninety-five (95) pounds shall be considered as constituting one (1) cubic foot of cement. The volume of coarse and fine aggregate shall be measured by shoveling into a box or bin without ramming or compacting.

(b) *Cement*.—All cement used in the work heretofore described shall be of the best quality of American Portland cement. It shall be finely ground, thoroughly burned and sufficiently slow setting to permit of working into mortar and using on the work before setting shall begin.

Storage.—All cement shall be furnished in well made bags or barrels bearing the name, brand, or stamp of the manufacturer, and shall be stored in a storage room or ware house to be provided by the contractor, and which will fully protect the cement from the weather. Said warehouse shall be provided with a floor so that the cement will be kept from contact with the ground.

Delivery.—All cement used in the work shall be delivered at the storehouse at least seven (7) days before it shall be used so that sufficient time will be available for its examination and testing.

Cement which becomes injured in storage and all rejected cement must be removed within three (3) days after notice to the contractor of its rejection.

Tests.—All cement used in the work shall be subject to the latest standard of tests as prescribed and adopted by the American Society of Civil Engineers. Any cement failing to pass any of the requirements above specified may be rejected.

(c) *Aggregates*.—Before delivery at the work, the contractor shall submit to the engineers a fifty pound (50 lb.) sample of each kind of aggregate proposed to be used. These samples will be tested and if found to pass the requirements of the specifications shall be considered as acceptable for the work.

Fine Aggregate.—Fine aggregate shall consist of natural sand, or screenings from hard, tough durable crushed rock or gravel, consisting of quartzite grains, or other equally hard material graded from fine to coarse with the coarse particles predominating. Fine aggregate, when dry, shall pass a screen having four (4) meshes per linear inch; not more than twenty-five (25) per cent. shall pass a sieve having fifty (50) meshes per linear inch, and not more than five (5) per cent. shall pass a seive having one hundred (100) meshes per linear inch. Fine aggregate shall not contain vegetable or other deleterious matter, nor more than three (3) per cent. of clay or loam.

Fine aggregate shall be of such quality that mortar composed of one (1) part of Portland cement, and three (3) parts fine aggregate, by weight, when made into briquettes, shall show a tensile strength at seven (7) and twenty-eight (28) days at least equal to the strength of briquettes composed of one (1) part of the same cement and three (3) parts Standard Ottawa sand by weight. The percentage of water used in making the briquettes of cement and fine aggregate shall be such as to produce a mortar of the same consistency as that

of the Ottawa sand briquettes of standard consistency. In other respects all briquettes shall be made in accordance with the report of committee on uniform tests of cement of the American Society of Civil Engineers.

Coarse Aggregate.—Coarse aggregate shall consist of clean durable crushed rock or gravel graded in size, free from vegetable or other deleterious matter and shall contain no flat or elongated particles. The size of the coarse aggregate shall be such as will pass a one (1) inch round opening and shall range from one (1) inch down, not more than five per cent. (5%) passing a screen having four (4) meshes per linear inch.

(d) *Mixing Concrete.*—The materials composing the concrete shall be thoroughly mixed in a concrete "batch" mixer of an approved design and mixing shall continue at least one minute after all the materials are in the drum. In any event, mixing shall continue until the various ingredients have been thoroughly and evenly mixed and the mixture shall have a uniform color. The drum shall be completely emptied before the following batch is added.

Retempering of mortar or concrete which has partially hardened shall not be permitted.

The materials shall be mixed with sufficient water to produce a concrete which when deposited will settle to a flattened mass, but shall not be so wet as to cause a separation of the mortar from the coarse aggregate in handling and depositing.

All concrete mixed shall be subject to the inspection and approval of the engineers or inspectors.

(e) *Placing Concrete.*—All concrete shall be conveyed from the mixer and placed in such a manner as to reduce so far as practicable the separation of the ingredients composing the concrete. Suitable bulkheads or bond boxes shall be constructed wherever necessary. All work shall be laid out and carried out on lines to insure the greatest strength in the structure. Due consideration shall be given to points at which a day's run shall be stopped, and such points shall be subject to the approval of the engineers or inspector.

The concrete, except as specifically ordered, shall be sufficiently wet to flow readily and shall be cut down around the steel rods and next the forms with cutting spades and bars of proper size and design for such purpose. Extreme care must be taken to see that the concrete is spaded sufficiently to bring the mortar out to the forms and produce a smooth wall surface, and at the same time increase the water tightness of the wall.

The concrete in beams, roof slabs and walls shall be laid out in such sections as shall result in the greatest strength and the most satisfactory work, and shall be subject to the approval of the engineers.

When concrete is to be laid against a surface of concrete which is already set, said surface shall be carefully and thoroughly cleaned and washed and then carefully and completely covered with a coating of neat cement and water, laid on evenly with a broom or brush. Said coating of neat cement shall be added just before the new concrete is placed.

Noticeable voids or pockets discovered in the concrete when the forms are removed shall be immediately filled with mortar mixed in proportions of one (1) part of Portland cement to two (2) parts of sand.

Any cement, mortar or concrete, wholly or partially set before being placed, shall be removed and shall not be used in any portion of the work.

No concrete shall be placed in freezing weather or during such times when the temperature will reach as low as 32° F. during the night, unless specifically permitted by the engineers. In case permission is given to place concrete during the cold weather precautions must be taken to house and protect the concrete being placed from freezing. Fires or steam heating shall be used in that case to keep the newly placed concrete from being affected by the frost. The aggregate and water shall be heated sufficiently so that when the concrete is poured into the forms or deposited in place it shall be at a temperature not lower than 40° F., all concrete work permitted during freezing weather shall be in accordance with the directions and to the full satisfaction of the engineers.

(f) *Forms*.—All necessary forms and false work required shall be provided and erected by the contractor at his own cost and expense, and shall be of suitable design and strength to shape the walls, beams and other parts of the work in the manner shown in the drawings. All forms shall be well braced and strengthened and shall be carefully matched or surfaced in order to prevent leakage of mortar. It is particularly important that the forms be absolutely tight to prevent the leakage of mortar as the loss of mortar will decrease the water tightness of the work.

All forms shall be built true to line and grade and shall be sufficiently braced to preserve said line and grade while the concrete is being placed and until such time as the concrete has completely set. In case any form should give way and produce irregular shapes, or leak and produce a faulty structure, said work shall be remedied by the removal of the irregular or faulty portion. The forms shall be built from lumber smoothly dressed on the side next the concrete, and shall be constructed so that the resulting structure shall present a smooth, even and workmanlike appearance.

All forms shall be left in place until the concrete has attained sufficient strength to resist accidental injury and permanent stresses that may come upon it.

Forms shall be carefully and thoroughly cleaned before being used again, and shall not be used again when warped or injured, without satisfactory repairs.

(g) *Top Finish of Concrete*.—The top of the roof and the floors shall be brought to the lines and grades indicated on the plans and due care must be taken with the roof not to permit any hollows or low spots in which the water may collect and stand. The roof shall slope uniformly from the center to the sides as shown on the drawings.

The surface of the roofs and the floors shall be brought to the proper elevation and then carefully rodded and screeded off to a uniform surface, after which the surface shall be smoothed down with a float. The finished concrete shall be smooth and have an even surface. It is not intended to add a layer of mortar, but it is intended to float the concrete mixture sufficiently to bring the mortar to the surface.

(h) *Protection of Finished Concrete.*—All concrete floors and roofs shall be protected from accidental injury. All freshly poured concrete shall be protected from the heat of the sun by the use of canvas, paper or sand, and shall be thoroughly wet down every twelve (12) hours for at least forty-eight (48) hours after the concrete has been poured.

All concrete work shall become sufficiently hard to prevent injury by workmen before walking or passing over it is permitted.

6. *Water Proofing.*—It is intended to water proof the side walls of the reservoir from the floor up to elevation 16.5, city datum, and the side walls of the suction well from elevation 8 to elevation 16.5, city datum, with hydrated lime. The hydrated lime shall be added to the cement at the time the cement is placed in the mixer. The hydrated lime shall be of an approved brand and shall pass the Standard Specifications for Hydrated Lime of the American Society for Testing Materials.

The hydrated lime shall be added in the proportions of one (1) part of hydrated lime to ten (10) parts of Portland cement. The proportions above given shall be by volumetric measurement made by shoveling into a suitable box without packing and care shall be taken to see that the above mentioned proportions are used in every batch.

After the forms have been removed the inside face of the reservoir walls and the inside face of the suction well walls shall be given two (2) coats of neat cement wash. The cement shall be mixed with only sufficient water to make a mixture that can be applied with a brush. The cement wash shall be evenly and thoroughly applied so as to fill the pores of the concrete and increase the water tightness of the walls. The second coat shall be applied after the first coat has thoroughly dried.

7. *Steel Reinforcing Rods.*—There shall be built into the concrete at the points shown on the drawings, and as directed by the engineers, round steel rods of the dimensions indicated. The steel for these rods shall have an ultimate strength of from 55,000 to 63,000 pounds per square inch and shall be of the quality known as medium steel. The rods shall be commercial round steel rods, free from oil, dirt or loose rust, and shall be equal to the best of their class in the market. All rods shall be held to their proper position by clips and wires fastened to the forms. The engineer may increase or decrease the amount of steel reinforcement as in his judgment seems necessary. Additions or deductions in the price paid shall be made for such additions or deductions in the amount of reinforcement in accordance with the prices stated therefor in the proposal.

The contractor may, if he desires, submit a bid upon twisted or other deformed bars of medium quality of steel and of equivalent cross section. Due consideration will be given said bid in lieu of the plain round rods as heretofore specified.

When a continuous line of reinforcement is desired the rods shall be lapped not less than forty-five (45) diameters for plain rods and thirty-five (35) diameters for deformed bars, and shall be securely wired or otherwise fastened together in a manner approved by the engineers.

8. *Manholes*.—Seven (7) standard cast iron manholes and covers shall be furnished and placed by the contractor at the points indicated on the drawings, or as directed by the engineer. The manholes shall each have an opening approximately twenty-four inches (24") in diameter, and the covers shall be perforated for the admission of air for ventilating purposes. The cover shall be sufficiently strong to sustain a concentrated load of 300 pounds at the center.

The contractor shall furnish and place the manhole frame and cover for the suction well as indicated on the drawings.

9. *Gutter*.—A gutter constructed of fifteen (15) inch vitrified gutter pipe shall be constructed along one side of the reservoir and for part of the length of the other side as indicated on the drawings.

The gutter shall be laid to the line and grade to be given by the engineers. The joints shall be laid with mortar mixed in the proportions of one (1) part Portland cement to two (2) parts of sand of the quality hereinbefore mentioned. A small strip of concrete shall be placed on both sides of the gutter as indicated on the plans, and said concrete shall be mixed in the proportion of one (1) part of Portland cement to two and one-half ($2\frac{1}{2}$) parts of sand to five (5) parts of stone or gravel.

The gutters shall be connected to the storm water sewer by eight inch (8") vitrified sewer pipe, as indicated on the plans. A suitable cast iron connection shall be provided to connect the gutter to the eight inch (8") sewer pipe and said connections shall be provided with suitable grating with a net water way equal to sixty (60) square inches.

10. *Cast Iron Pipe*.—The contractor shall furnish and place one (1) twelve foot length of Class B thirty-inch (30") cast iron water pipe. Said pipe shall be supplied with a suitable collar or flange at least twelve inches (12") larger in diameter than the outside diameter of the pipe. Said collar shall be either cast as a part of the pipe or shall be so constructed that a lead joint may be poured and calked between the outside of the pipe and the inside face of the collar.

The length of pipe shall be carefully aligned and placed to the proper grade and when so placed shall be held rigidly in place during the time the concrete is being poured.

The contractor shall furnish and place seven (7) lengths of Class B twenty inch (20") cast iron water pipe. One (1) length shall be furnished with a suitable collar of the type above mentioned. The pipe shall be laid on top of the reservoir floor and at the end it shall have a ninety degree (90°) bend, placed with the outlet turned up. All joints are to be filled with lead and thoroughly calked so as to produce a tight joint.

The pipe, after being properly aligned and placed, shall be anchored to the floor of the reservoir by means of three (3) concrete blocks eighteen inches (18") wide, four feet (4') long and fifteen (15") high.

The contractor shall also furnish and place one (1) length of Class B thirty-inch (30") cast iron water pipe four feet (4') long with a standard flange faced and drilled A. S. M. E. on one end with a standard bell or hub on the other end.

The contractor shall furnish and place three (3) lengths of Class B twenty-four inch (24") cast iron water pipe four feet (4') long with standard flanges, faced and drilled A. S. M. E. on both ends.

The three (3) lengths of twenty-four inch (24") and the one (1) length of thirty inch (30") pipe above mentioned are to be furnished with suitable collars as previously described, and the contractor shall place them to the line and grade indicated on the drawings and as outlined by the engineers. Due care must be taken to see that the axis of the pipe is truly horizontal and remains so until the concrete is poured and has thoroughly set.

Before leaving the job, the contractor shall cover the ends of the pipes projecting outside the concrete structures by means of board covers securely fastened to the pipes to prevent sand entering the pipes.

11. *Sheeting and Pumping.*—The contractor shall provide all labor and materials necessary to properly sheet around the proposed work so as to excavate to the depth and lines indicated on the plans. Said sheeting shall be carried to such depth as to prevent the sand or other materials from coming into the portion excavated.

The contractor, at his own cost and expense, shall provide all necessary pumps to properly unwater the site and keep same free of water during such time as the work is under construction. The contractor shall provide all labor and materials to keep the site unwatered during the course of construction and shall provide all necessary bulkheads, drains, etc. to prevent running water from coming in contact with newly placed concrete, or concrete being placed. No concrete shall be placed in water if there is the least possible chance of the materials becoming separated. Under no circumstances shall the contractor place any concrete in water without the express permission of the engineers.

12. *Protection of Present Reservoir.*—The concrete in the present reservoir is of rather poor quality and it is uncertain whether the side walls will be self-sustaining with the earthen embankment removed from the wall on the northeast side. The contractor will be required, at his own cost and expense, to take such necessary precautions to brace the above mentioned wall sufficiently to withstand the pressure of the water when the reservoir is filled to elevation 9.5, city datum. Such bracing may consist of a heavy wale placed against the wall at an elevation of 9.5 with heavy shores placed about sixteen feet (16') apart. Said shores shall be thoroughly braced and anchored at the foot to resist the thrust resulting from the water pressure. In any event, the contractor will be required to furnish sufficient bracing of suitable kind to reinforce the present wall so that the old reservoir may be utilized and kept filled with water up to elevation 9.5.

13. *Timber Floor.*—In case the character of the ground in the bottom of the excavation for either or both the reservoir and the suction well is so soft and yielding that it will be impossible to secure a good job of concrete work for the floors, of which the engineers shall be the judge, then in that case a timber floor shall be constructed by the contractor over the entire area or areas. The contractor shall in that case provide all labor and materials necessary to construct said floor or floors.

The floor shall consist of one (1) thickness of one inch (1") hemlock matched lumber securely nailed to hemlock stringers two inches (2") by four inches (4") and spaced not more than four feet (4') apart. The hemlock lumber shall be of such nature that a tight floor will result.

The stringers are to be embedded in the earth and the ground leveled off to the top of said stringers. The tops of said stringers are to be placed one inch (1") below the bottom of the concrete floor. Care must be taken to see that the ground is carefully graded off to the top of the stringers so that the timber floor will have a uniform bearing.

Second hand lumber may be used in the construction of said floor provided the lumber is of such quality as will make a tight floor.

14. *Price and Measurement.* (a) *Reservoir.*—The lump sum price bid for the construction of the concrete reservoir shall include the cost of all labor and materials to properly excavate the site to the lines and grades shown on the drawings; said excavation work shall consist of loading the material into wagons or other means of conveyance but shall not include the cost of handling and depositing same. The lump sum bid shall include all labor, tools and materials necessary to sheet around the site of such portions as may require sheeting, and shall include the cost of all pumps, pumping machinery, labor and materials required to properly unwater and keep the site free from water.

Said lump sum shall include the cost of all labor, tools, plant machinery, forms and all materials necessary to make and deposit in place the concrete specified and to furnish and add the water proofing materials and shall include the cost of labor and materials required to add the wash coat of neat cement.

Said lump sum shall also include the cost of all labor and materials necessary to furnish and place all reinforcing rods, the iron ladder, the cast iron manholes, the cast iron water pipe, the vitrified gutter pipe and the sewer pipe and connections to the storm water sewer.

Said lump sum shall also include all necessary bracing of every kind necessary to properly reinforce the northeast wall of the existing reservoir during such time as the new reservoir is being built.

It is intended that the lump sum bid shall cover the entire cost of the completed structure except for the item of hauling and depositing the materials excavated and the cost of the timber floor.

(b) *Suction Well.*—The lump sum bid by the contractor for the suction well shall include the cost of all labor, tools, plant, machinery and materials necessary to properly sheet around the proposed pit; excavate the material and load same on a wagon or other means of conveyance, unwater and keep the site free of water, make and deposit all the concrete and reinforcing steel, and provide and add the water-proofing material and apply the cement wash coats.

Said lump sum shall also include the cost of furnishing and placing the cast iron pipe and collars hereinbefore mentioned and the steel manhole frame and cover and the necessary ladder, all as shown on the accompanying drawings.

It is intended that the lump sum bid shall include the cost of the completed suction well in accordance with the plans and specifications, with the exception of hauling the material excavated and constructing the timber floor.

(c) *Hauling and Depositing Excavated Material*.—All material excavated and not required for back filling shall be and remain the property of the city and shall be hauled and deposited at the site or sites selected by the city and as specified by the engineer. All material hauled shall be at the price named by the contractor and such price shall cover the entire cost of hauling and depositing the material at said site or sites.

(d) *Timber Floor*.—The price bid by the contractor for the timber floors shall include the cost of all labor and materials necessary to construct the timber floors in case they are ordered constructed by the engineer.

(e) *Extra Work*.—All work ordered by the engineers and not included under any of the previous headings or under the prices bid by the contractor, and which logically comes under this contract, shall be paid for on the basis of cost plus the percentage bid by the contractor. The cost of this extra work shall be calculated on the basis of the price paid all laborers and foremen actually engaged on this particular work, a part of the cost of the superintendent and time keeper; said part to be charged as extra work shall be the proportional part of the entire amount paid said superintendent and time-keeper that the field pay roll of the extra work bears to the entire field pay roll for the days that said extra work is being performed. The cost shall also include the price of any small tools, such as picks, shovels and hammers that may be worn out or lost by the men actually engaged on said extra work during such time as they are engaged on said extra work.

Said extra cost shall include the cost of any lumber, hardware, cement, gravel or any other material used and incorporated in said extra work. The cost shall include all liability insurance actually paid on the laborers and foremen engaged on said extra work.

Said cost of extra work shall not include any overhead, carrying, general or general office expense.

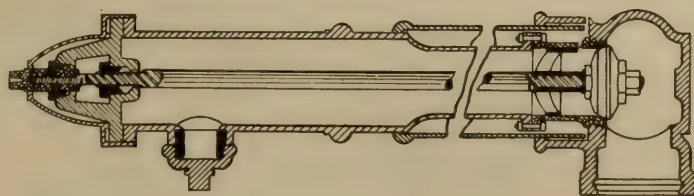
The percentage added to the cost shall cover all rental for any plant, machinery or large tools furnished by the contractor and used by him on said extra work. No additional charges for rentals will be allowed but said extra cost shall include the expenses of all ordinary renewals or repairs made to the machinery or equipment and caused by the use of the machinery and equipment while actually used on said extra work.

15. *Removal of Unused Material, Rubbish, etc.*.—All unused material, and all rubbish of any kind, must be removed and deposited in a place satisfactory to the superintendent of the water works, and in accordance with the city ordinances. The reservoir and suction well shall be thoroughly cleaned and left in a condition satisfactory to receive water. All work shall be left in a neat, clean and orderly condition.

APPENDIX C

DRAWINGS AS A BASIS FOR SPECIFICATION WRITING

The following drawings are furnished as a basis for the writing of specifications in order that the student may have a definite and distinct conception of the subject on which he is required to write. The student should be assigned one or more of these subjects and be required to write complete specifications of all or of such part of the same as may seem desirable.



Compression hydrant:
 6" pipe connection - 2-2 1/2" nozzles.
Cast iron:
 Base casting - stand pipe - frost case - caps and bonnet.
Bronze:
 Opening nut - holding-down nut - packing box gland - drip valve - drip valve chamber main valve seat - lock nuts and spindle bushings.
Steel - spindle.

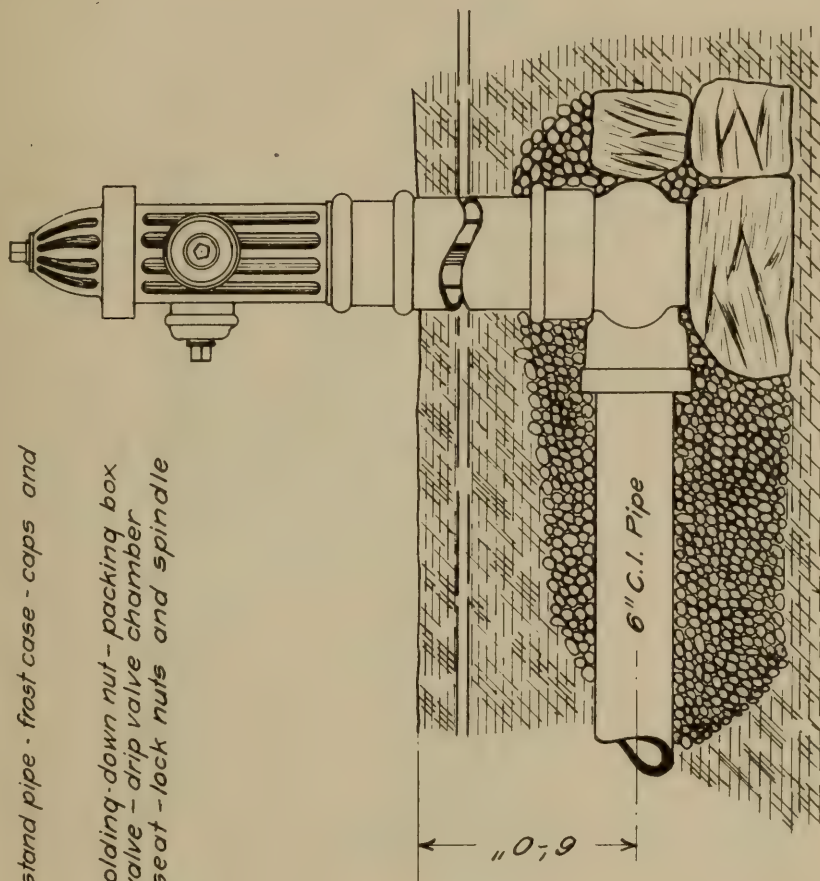


Fig. 1.—Hydrant Setting—Method for Clay or Impervious Material.

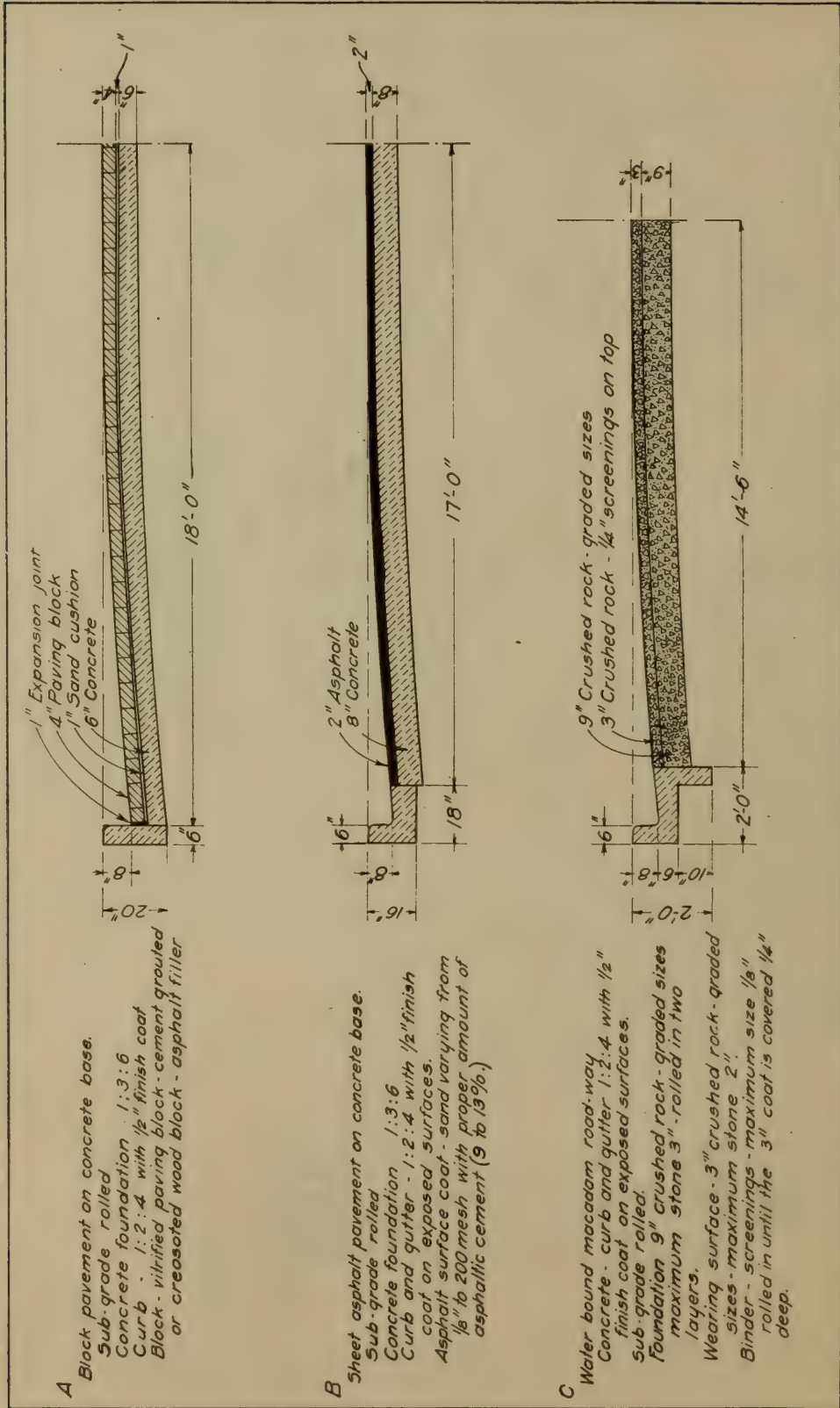


Fig. 2.—Street Pavements—Preparation of Sub-grade and Construction of Pavements for Types A, B and C.

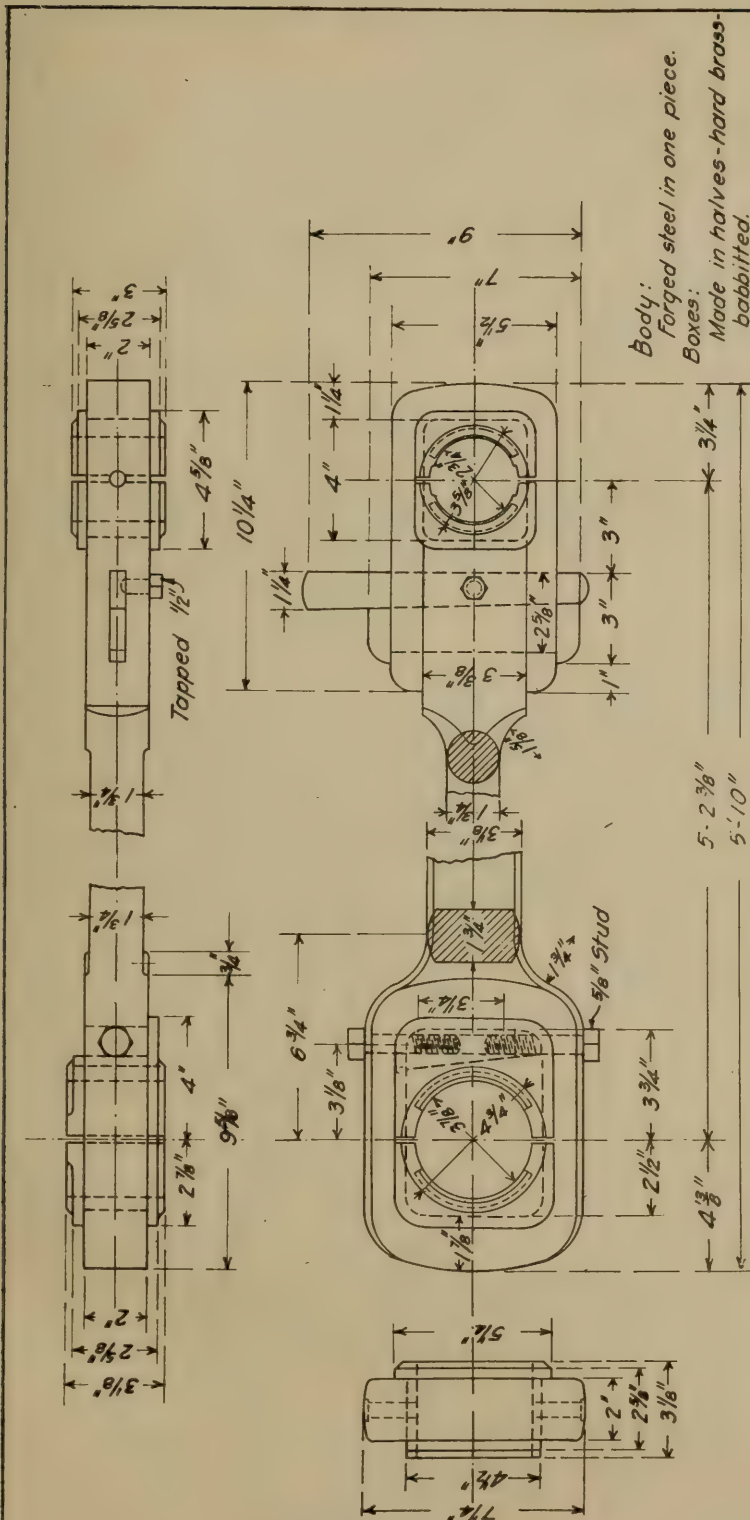


Fig. 3.—Engine Connecting Rod—Materials and Shop Work.

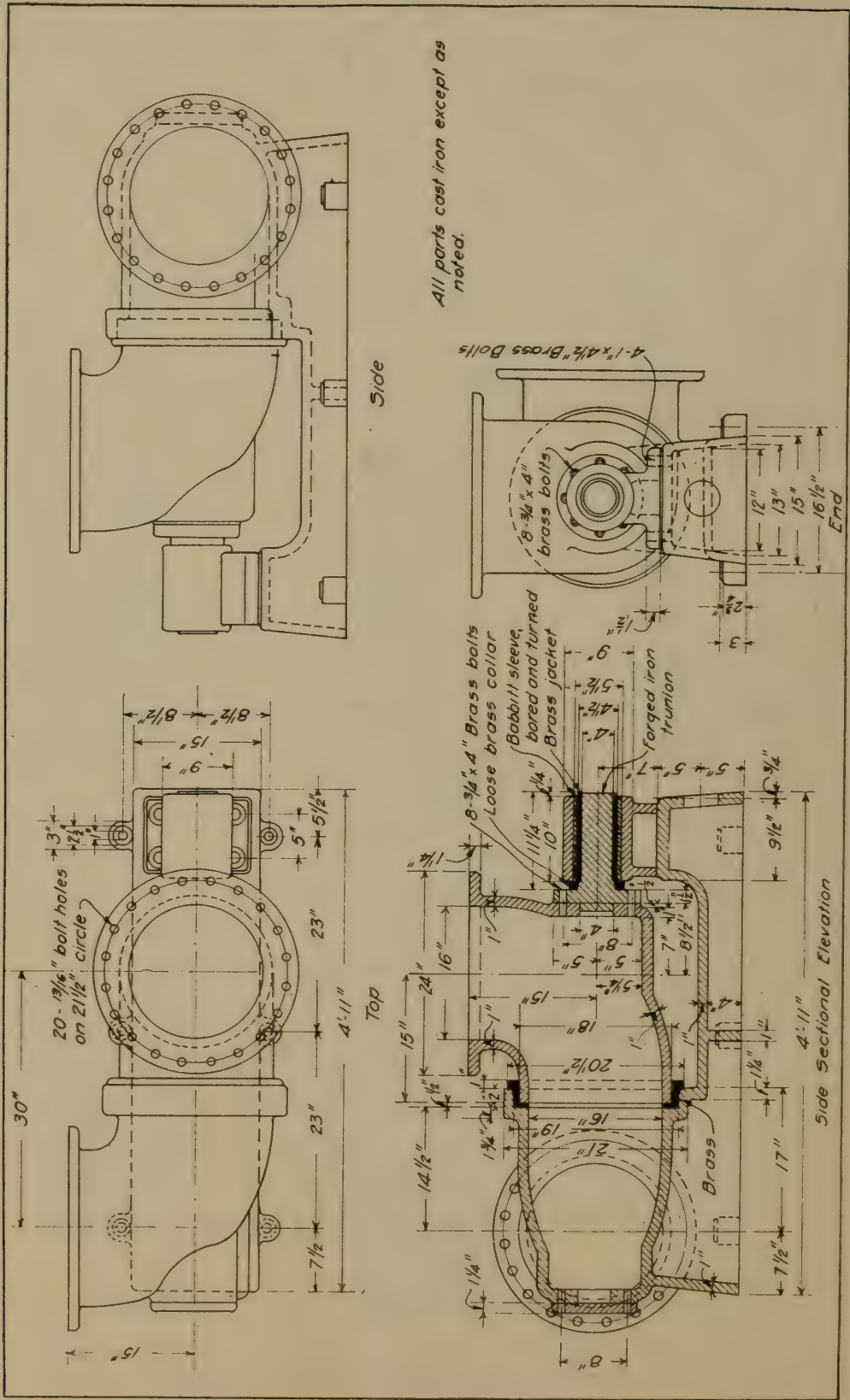


Fig. 4.—Rotating Pipe Joint—Materials and Workmanship.

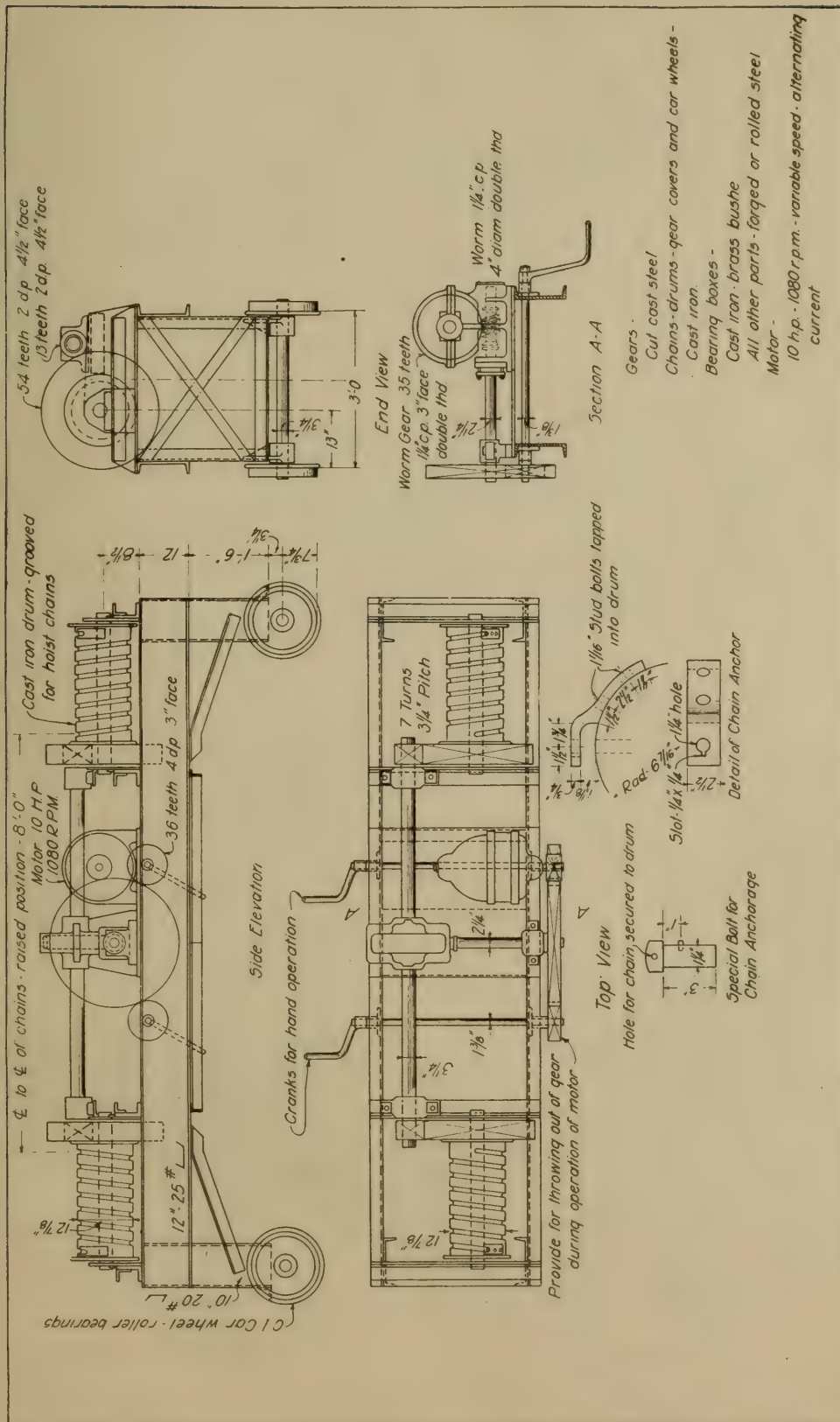


Fig. 5.—Tainter Gate Hoist—Materials, Workmanship and Motor.

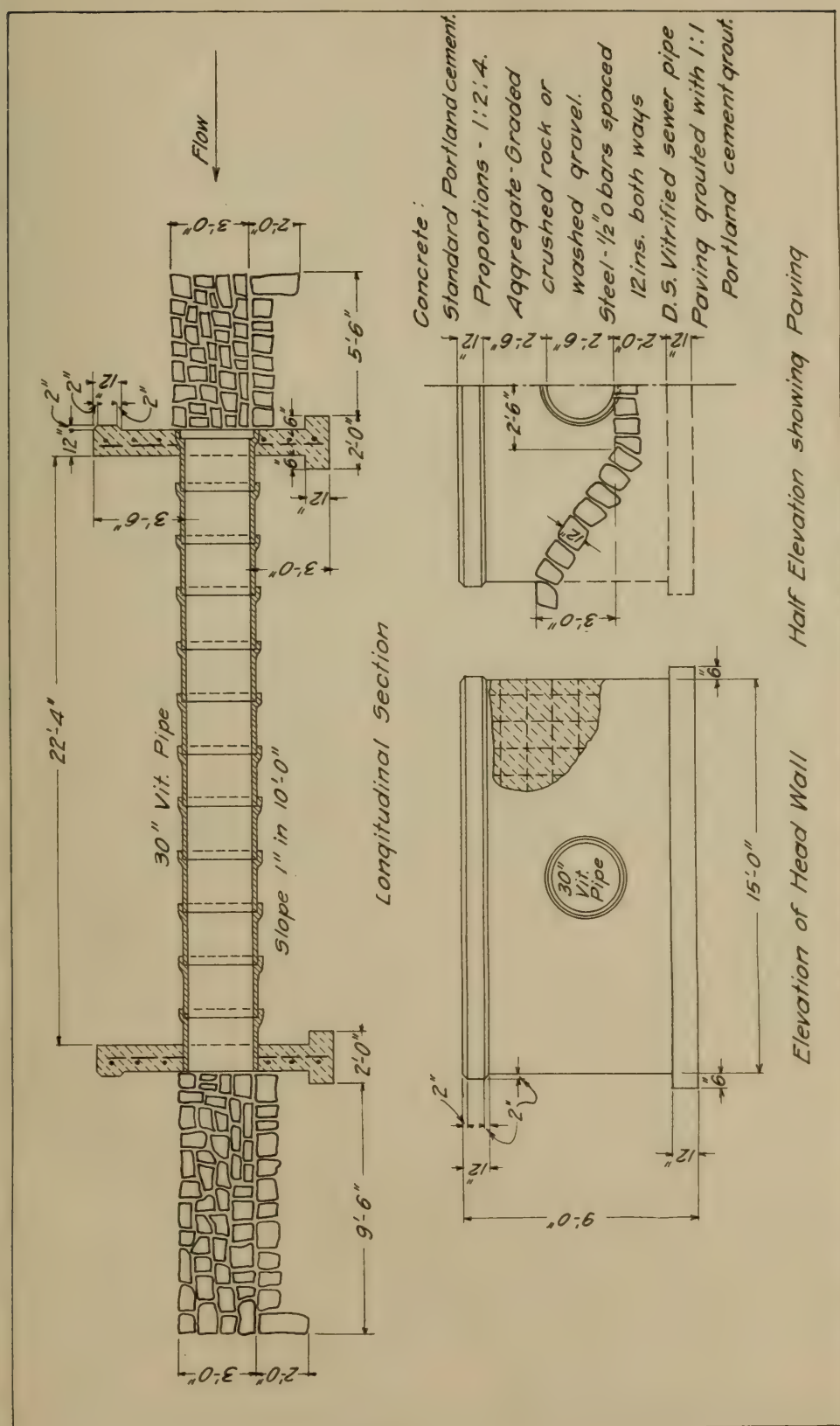


Fig. 7.—Vitrified Pipe Culvert Under Highway—Excavation, Materials.

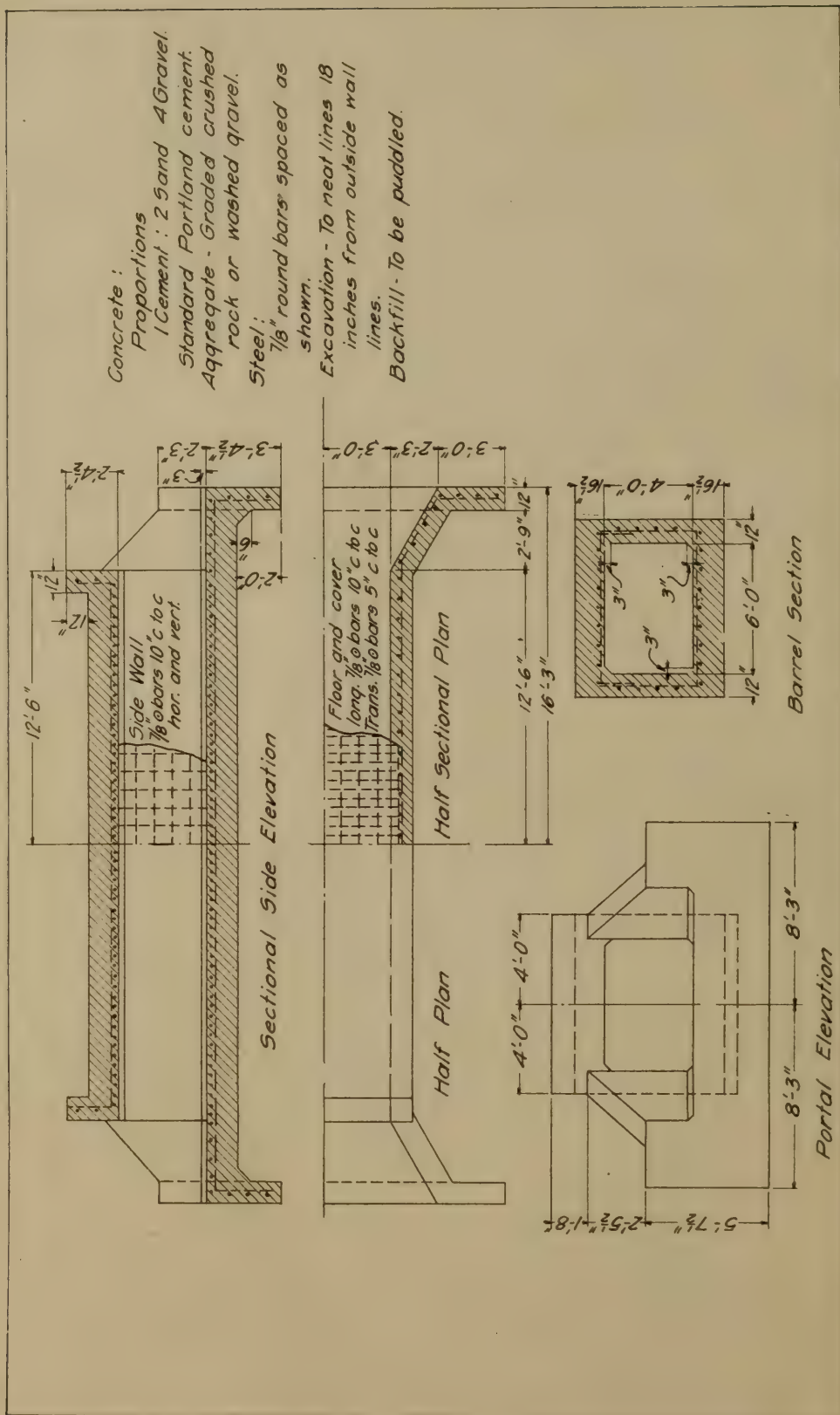


Fig. 8.—Reinforced Concrete Culvert Under Railway—Excavation, Backfill and Construction.

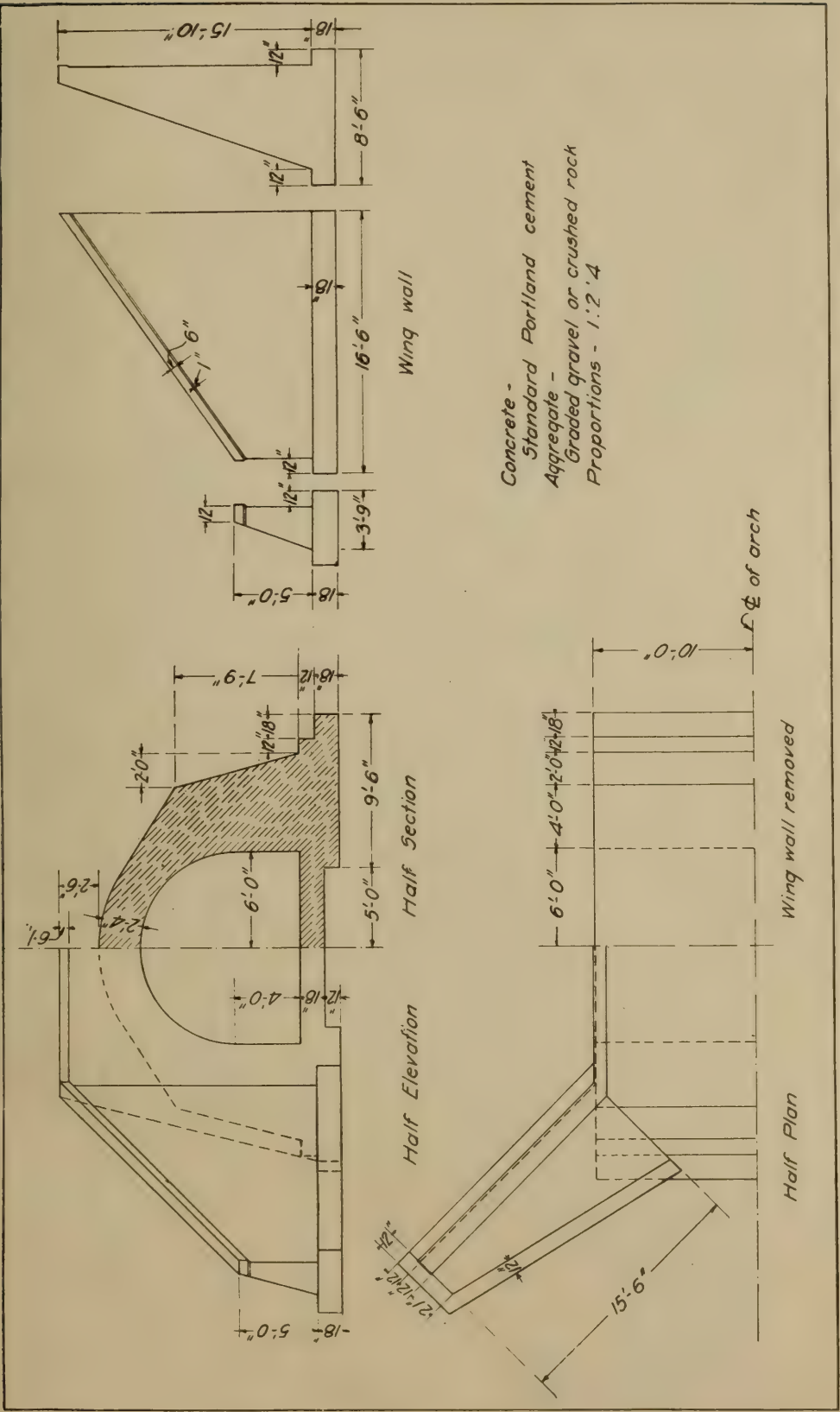


Fig. 9.—Plain Concrete Arch for Highway—Construction, Excavation and Backfill.

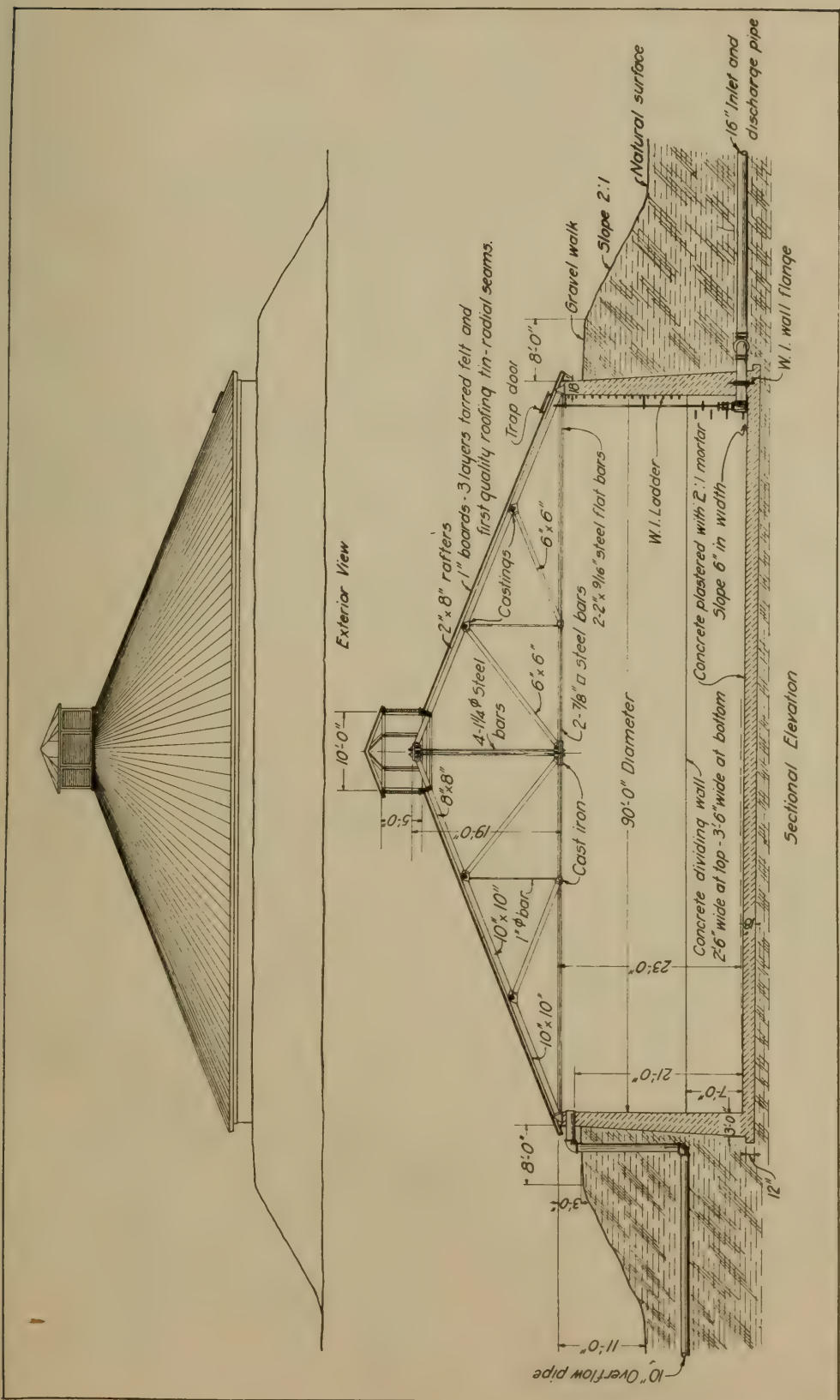


Fig. 11.—Circular Reservoir—Excavation and Backfill, Materials for and Construction of Concrete Floor and Walls—Combination Roof Trusses—Wrought Iron Ladder, Wall Flange and Trap Door. (See also Fig. 12).

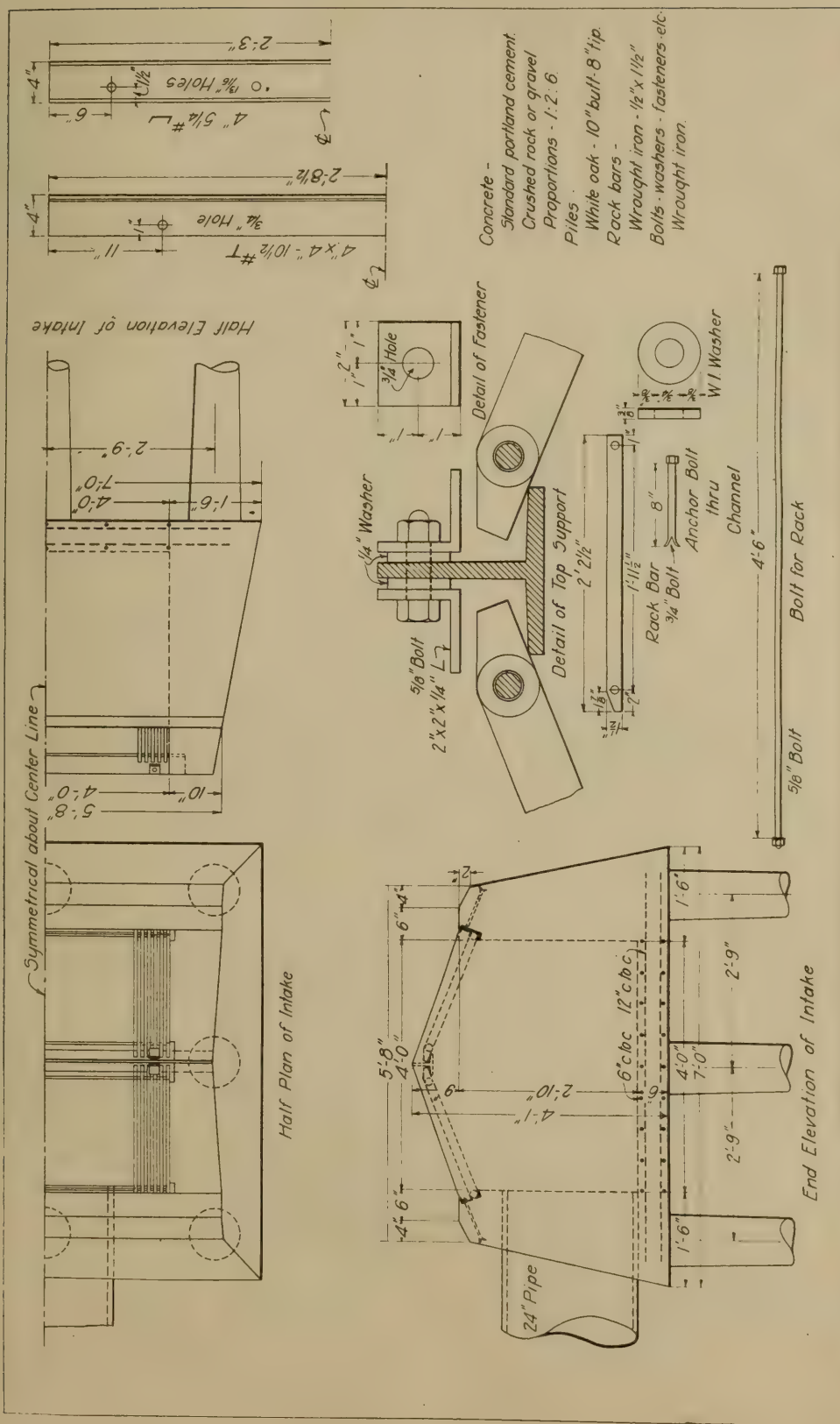


Fig. 13.—Concrete Water Supply Intake—Materials for and Construction of Pile Foundation, Concrete Cell and Rack Bar Cover.

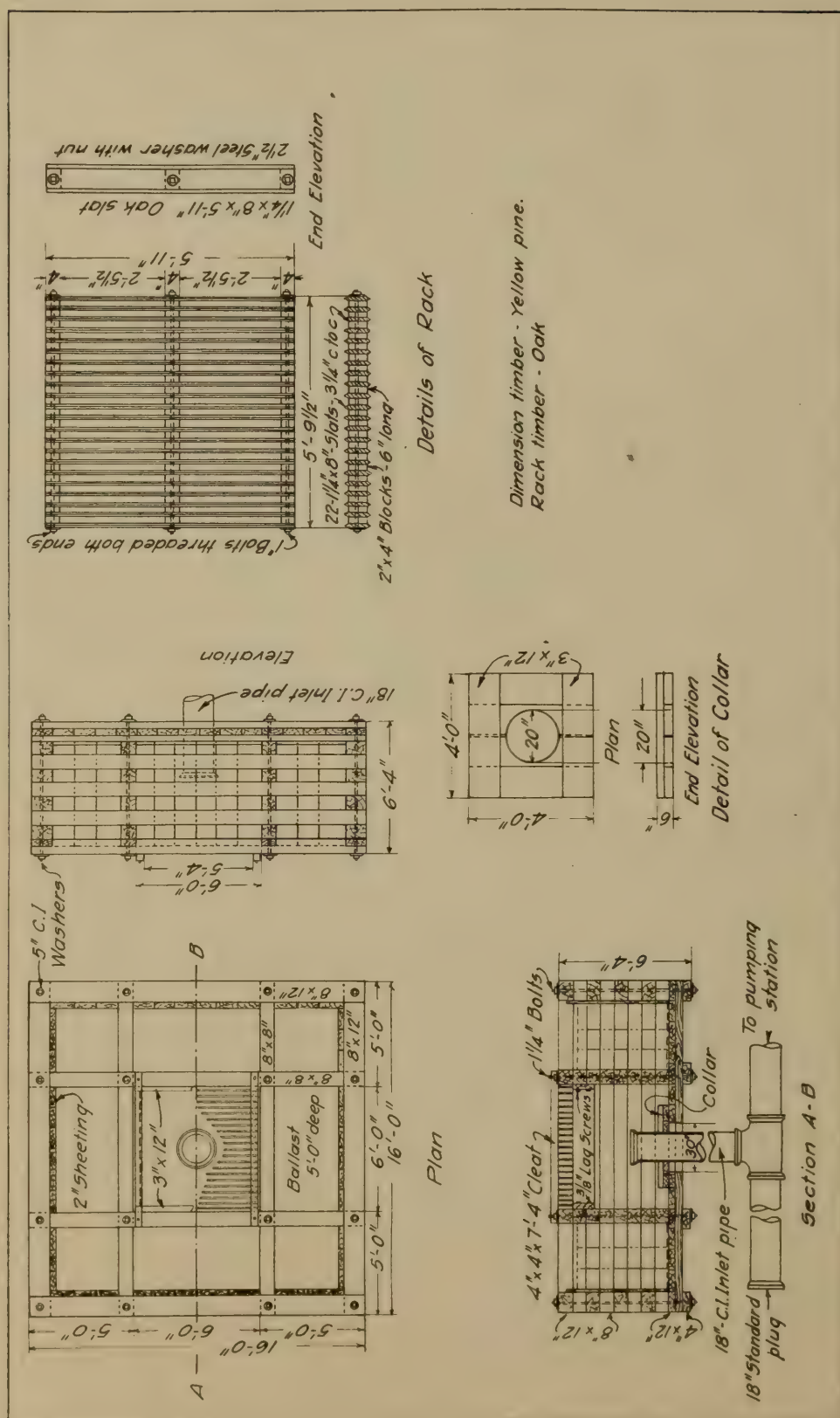


Fig. 14.—Timber-Crib Water Supply Intake—Materials for and Construction of Rock Filled Crib and Rack.

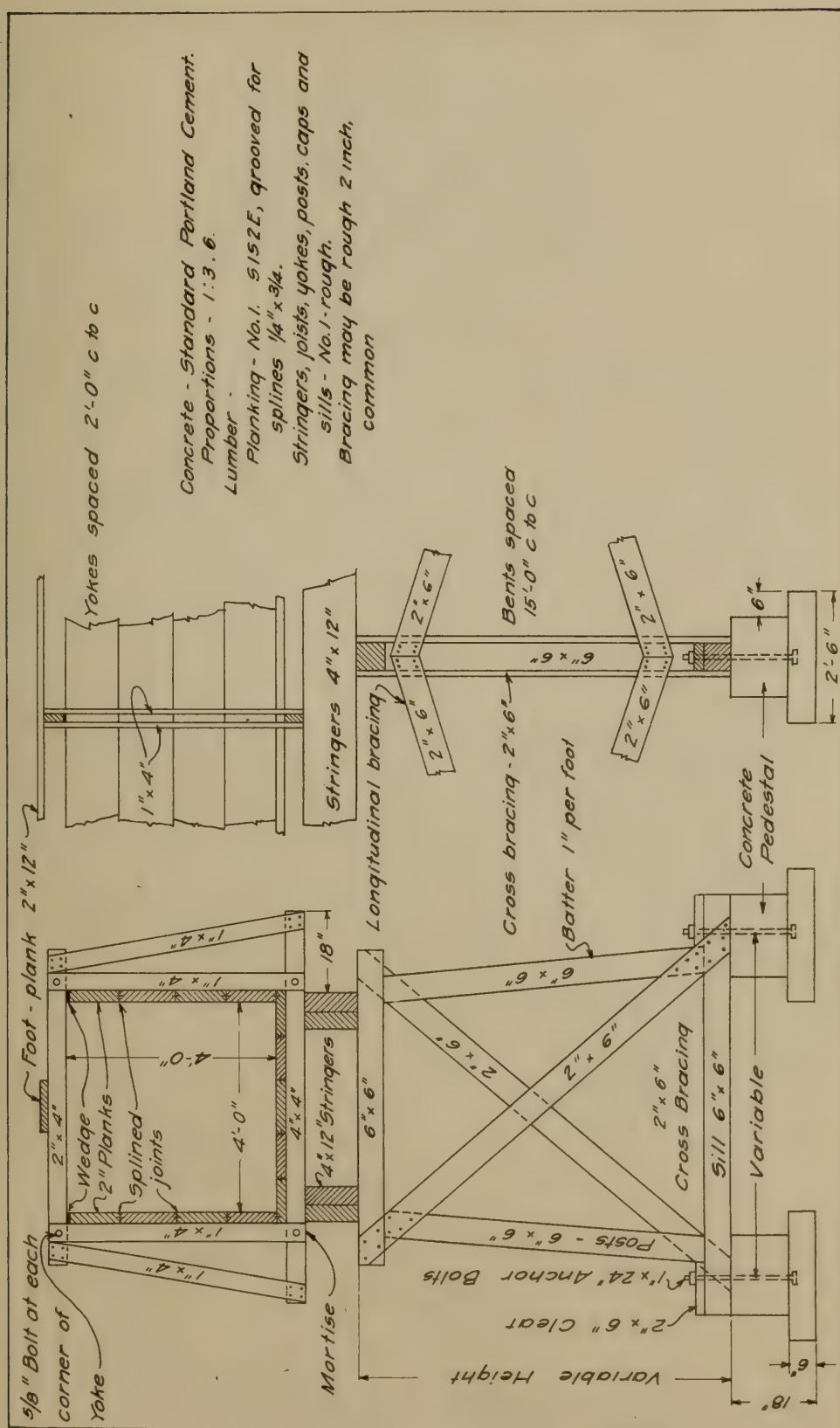


Fig. 15.—Timber Trestle and Flume—Materials for and Construction of Concrete Pedestals, Timber Trestle and Flume.

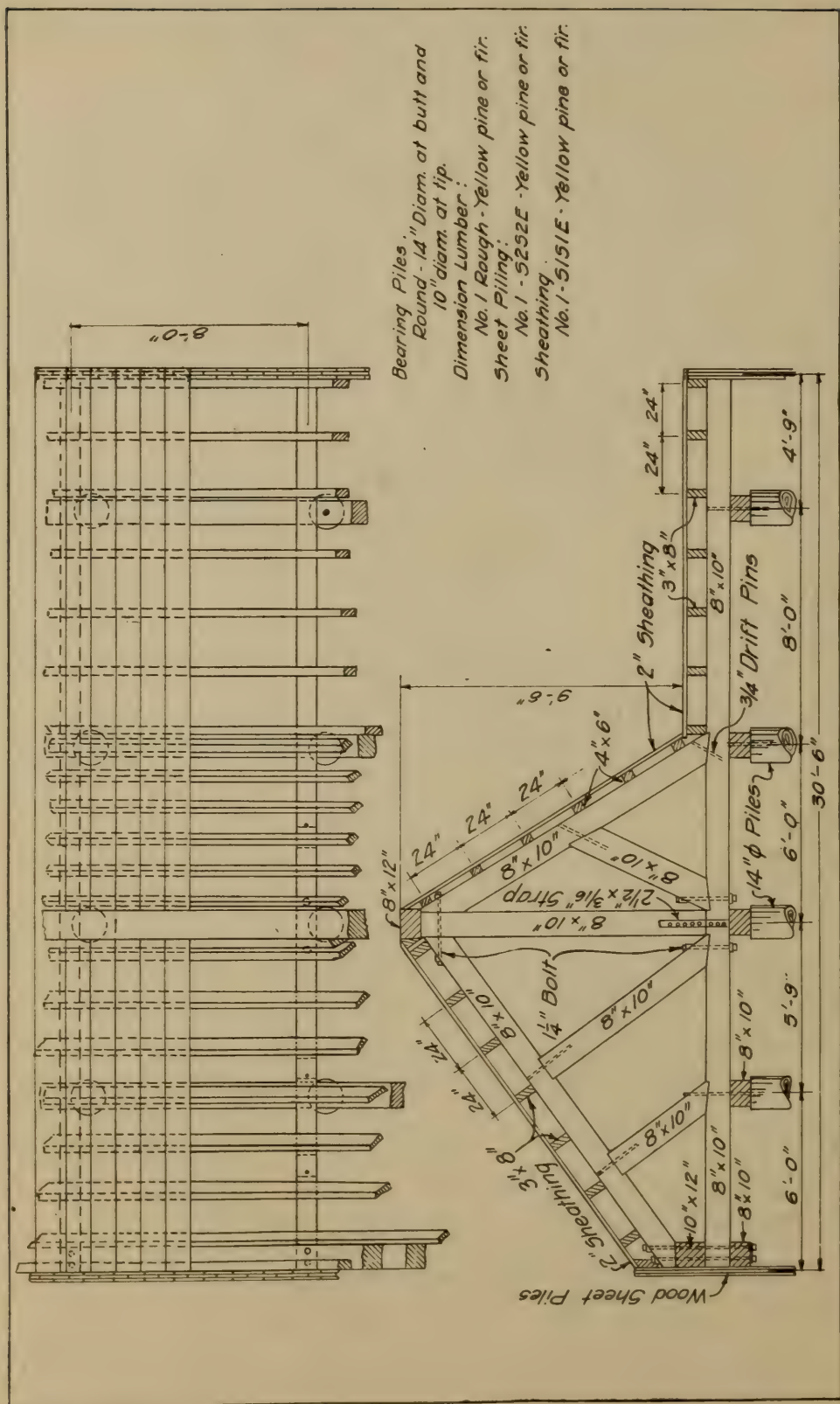


Fig. 16.—Timber Dam—Materials for and Construction of Pile Foundation, Sheet Pile Cutoff Walls, Timber Bents and Deck Sheathing.

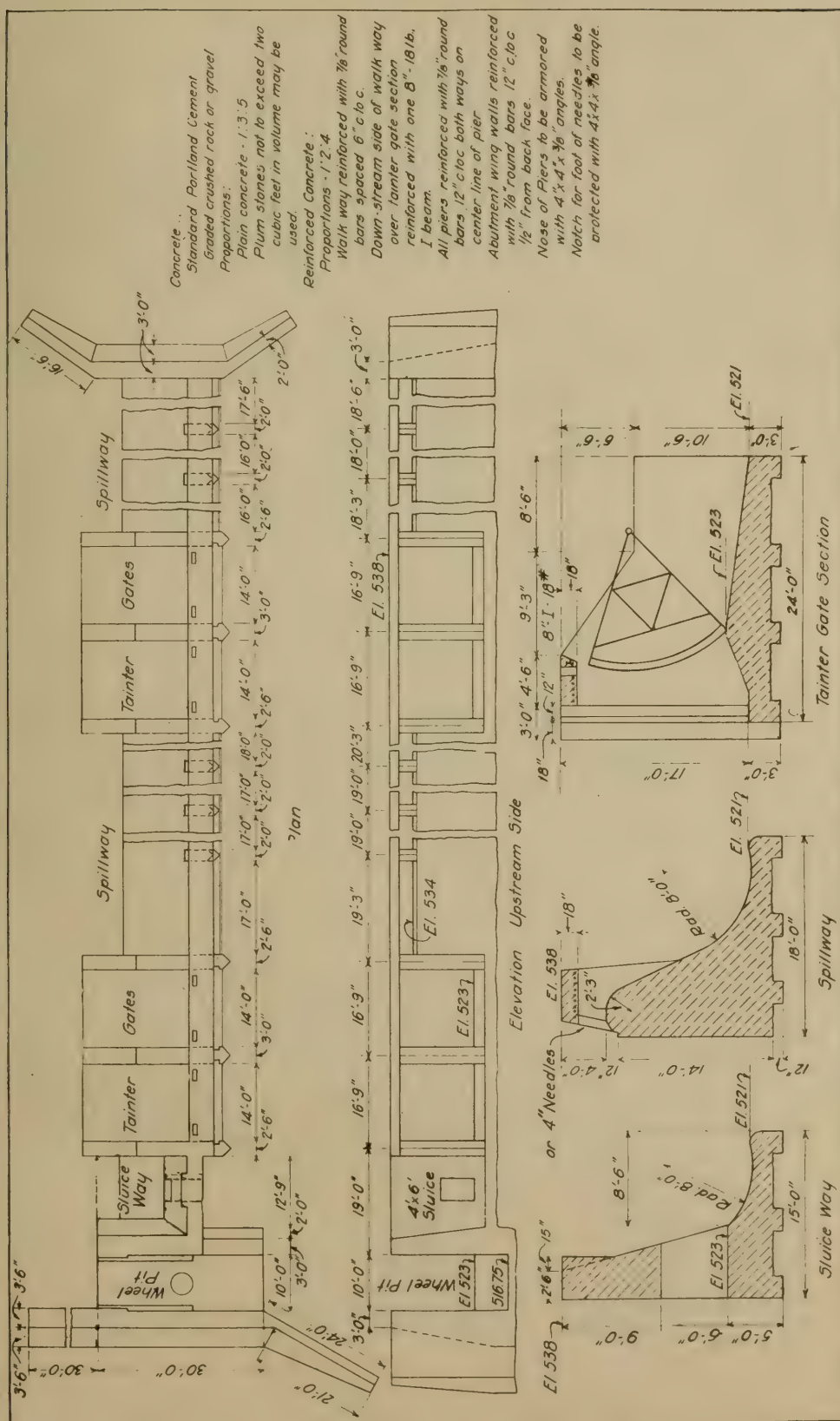


Fig. 17.—Concrete Dam—Preparation of Foundation, Ogee Spillway Section, Tainter Gate Section, Sluice Way, Wheel Pit and Wingwalls.

PUMPING STATION

The following Figures 19 to 24 inclusive are drawings for a water works pumping station. Specifications may be drawn for work and material for either the plant as a whole, or for the various parts according to the following schedule:

Building.

Excavation.

Foundations.

Concrete floors and walls.

Wooden floors.

Brick walls.

Cut stone.

Roof trusses.

Roof.

Machine foundations.

Stairways.

Railings.

Doors.

Windows.

Wainscoting.

Trim.

Gutters and downspouts.

Chimney.

Machinery.

Steam piping.

Water piping.

Sewer piping.

Breeching and smoke connection.

Boiler—125 H. P. return tubular.

Heater.

Engine—50 H. P. simple Corliss.

Triplex power pump, 500 gallons per minute, 200 ft. head.

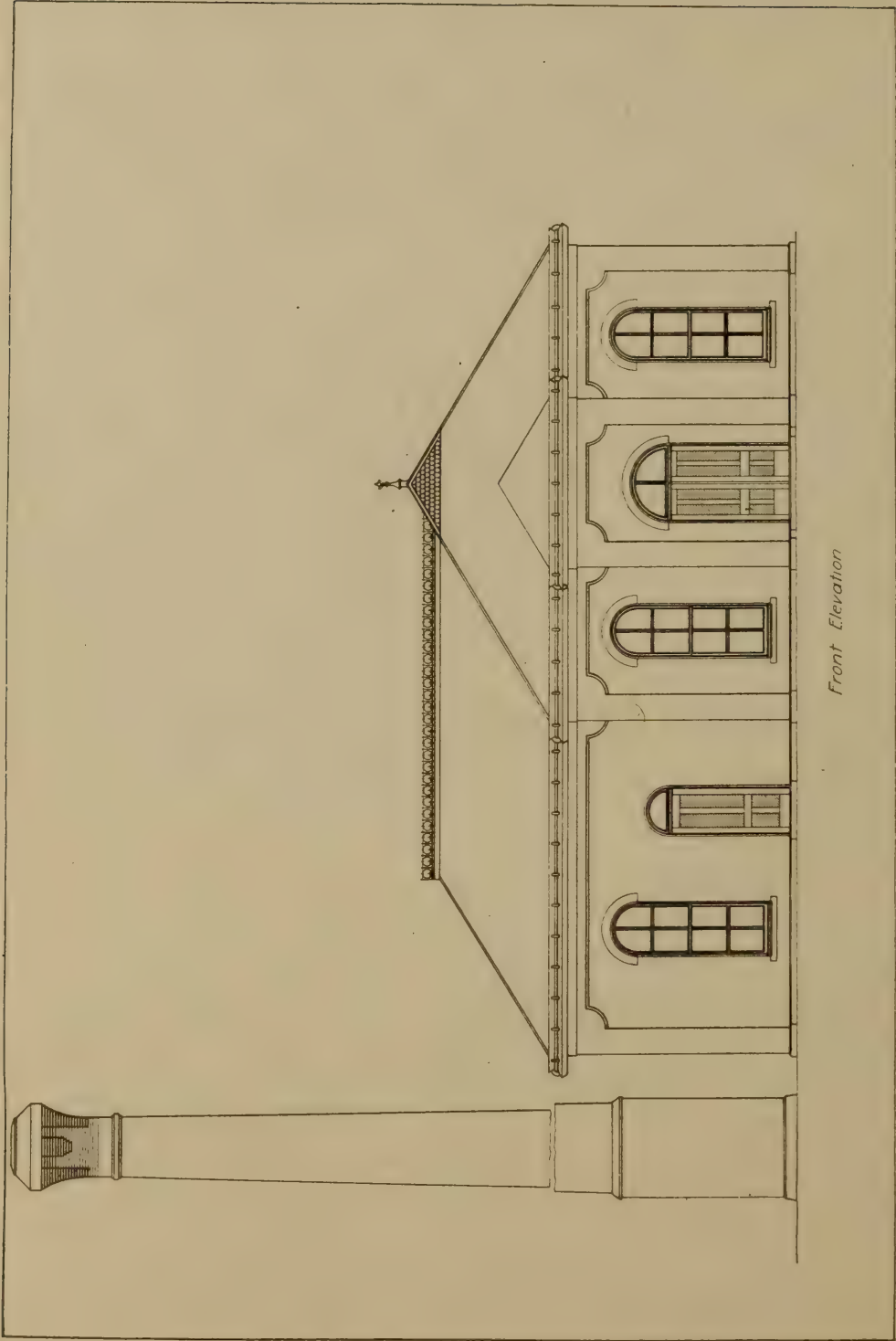


Fig. 19.—Water Works Pumping Station.

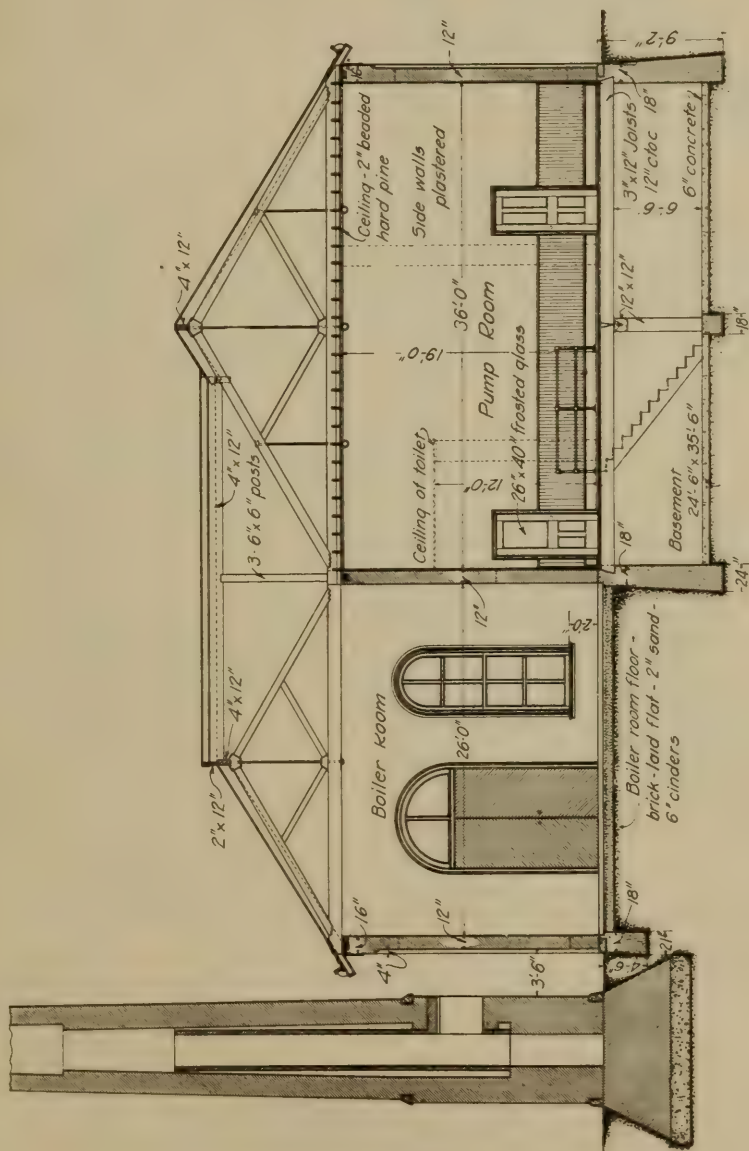


Fig. 20.—Water Works Pumping Station.

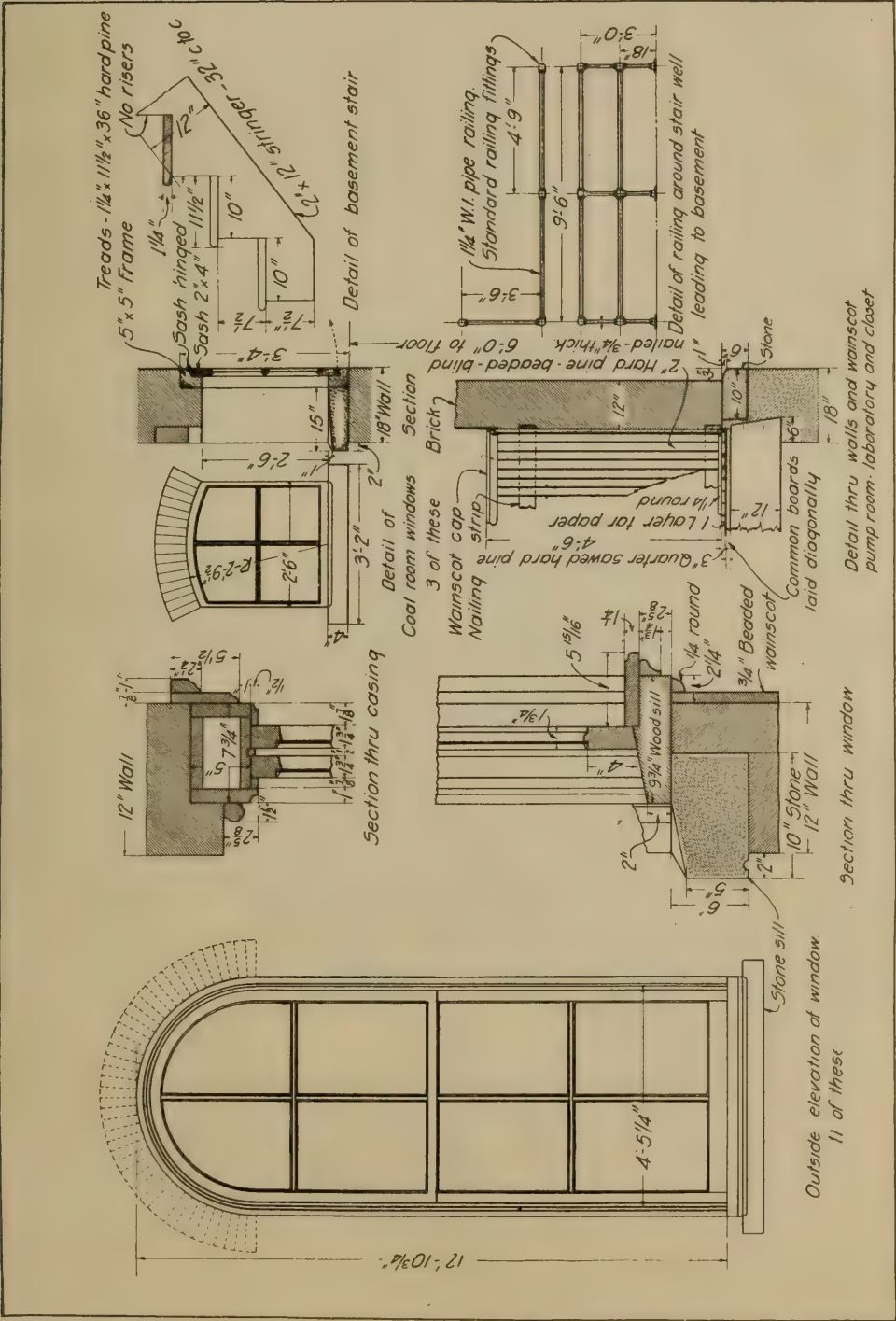


Fig. 22.—Water Works Pumping Station.

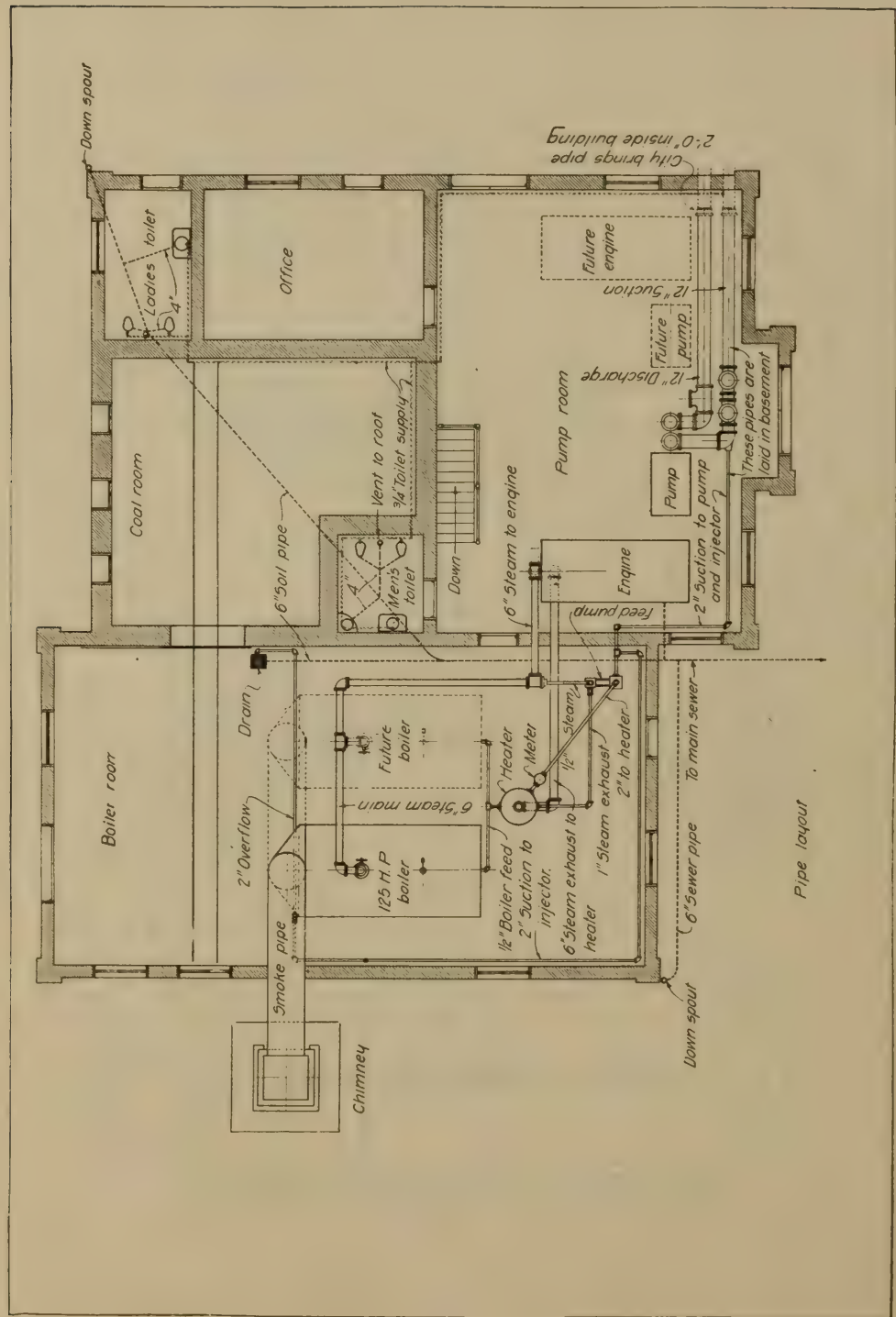


Fig. 23.—Water Works Pumping Station.

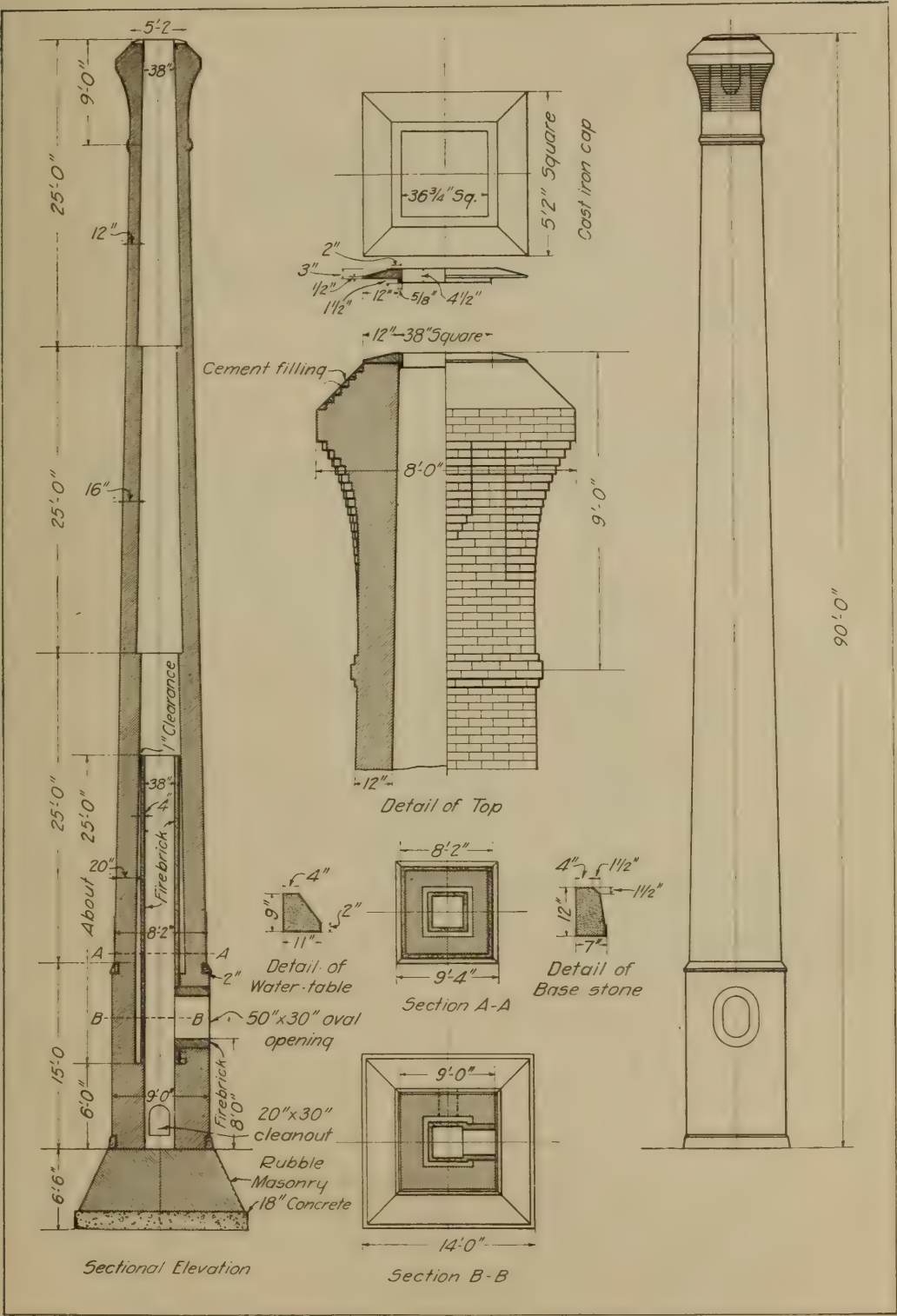


Fig. 24.—Water Works Pumping Station, Chimney.

WATER POWER PLANT

The following Figures 25 to 28 inclusive show four views of a vertical turbine setting with plate steel bulkhead, timber penstock gates, trash racks, etc. Specifications may be drawn for either the complete structure or its various parts as given in the following schedule:

Rock and earth excavation.

Concrete.

Plate steel bulkhead and other wrought iron work.

Trash racks and supports.

Cast iron.

Timber gates and other timber work.

Harness or power transmission machinery.

Gate lifting devices.

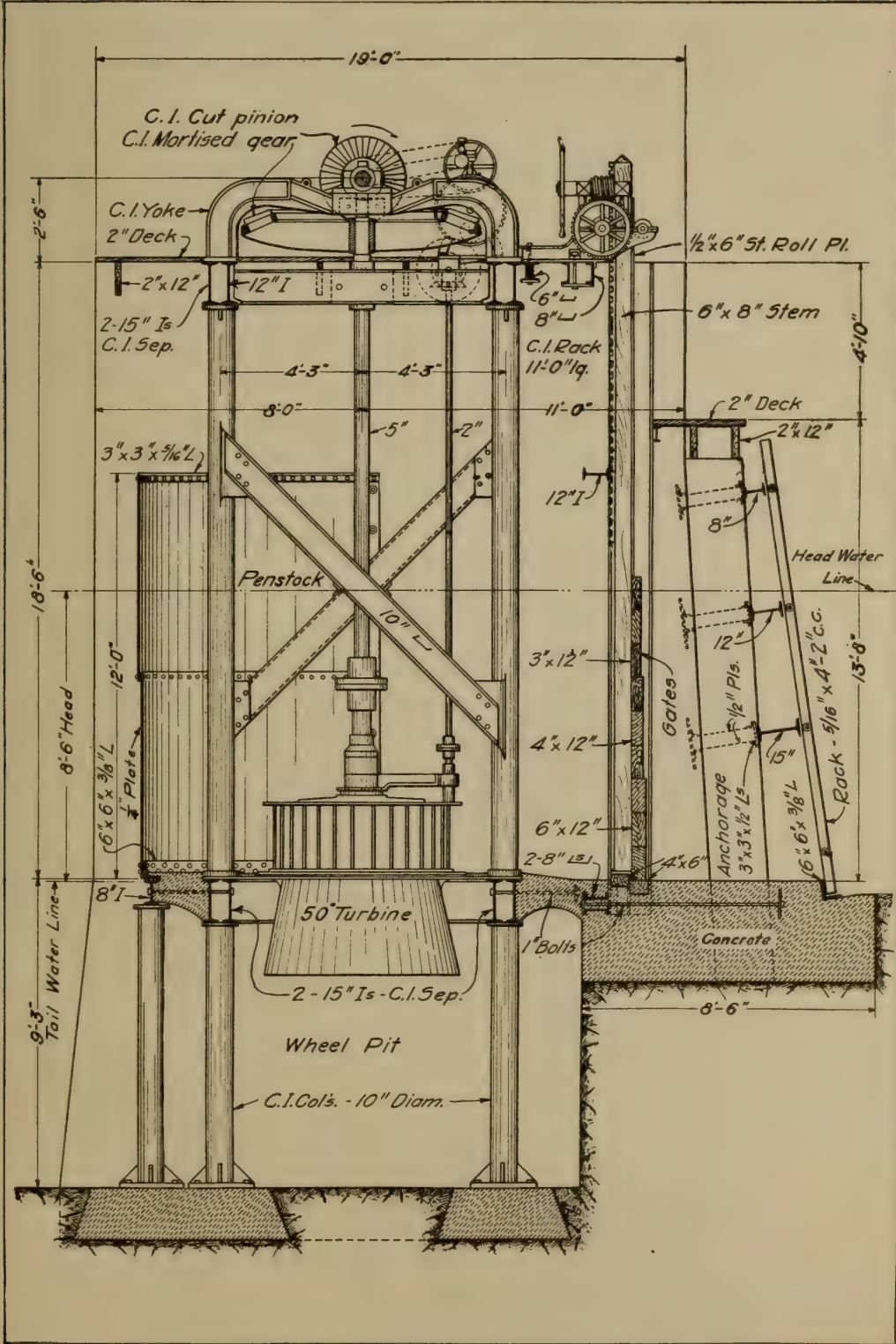


Fig. 25.—Vertical Turbine Setting—Sectional Elevation Through Wheel-pit and Bulkhead.

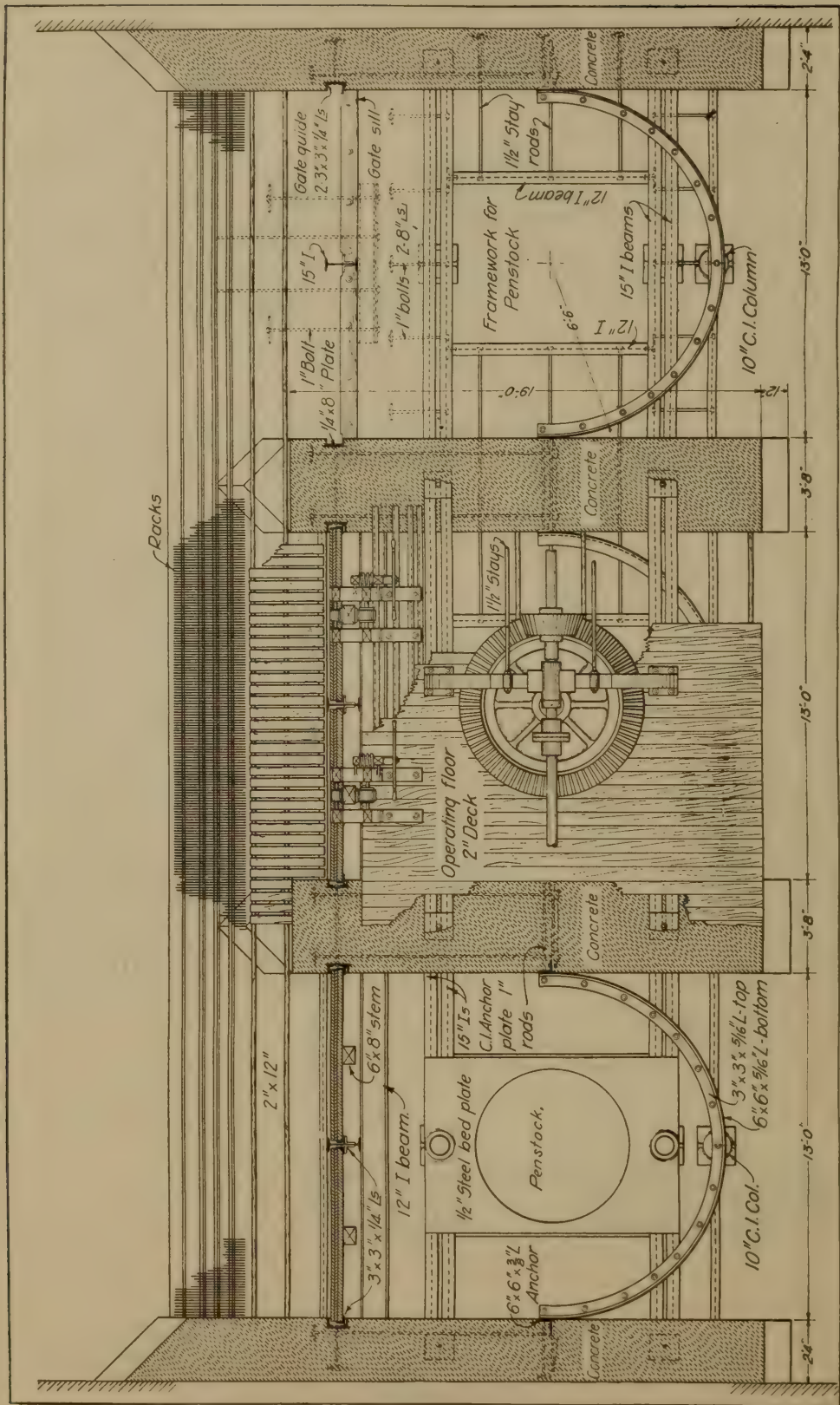


Fig. 26.—Vertical Turbine Setting—Plan.

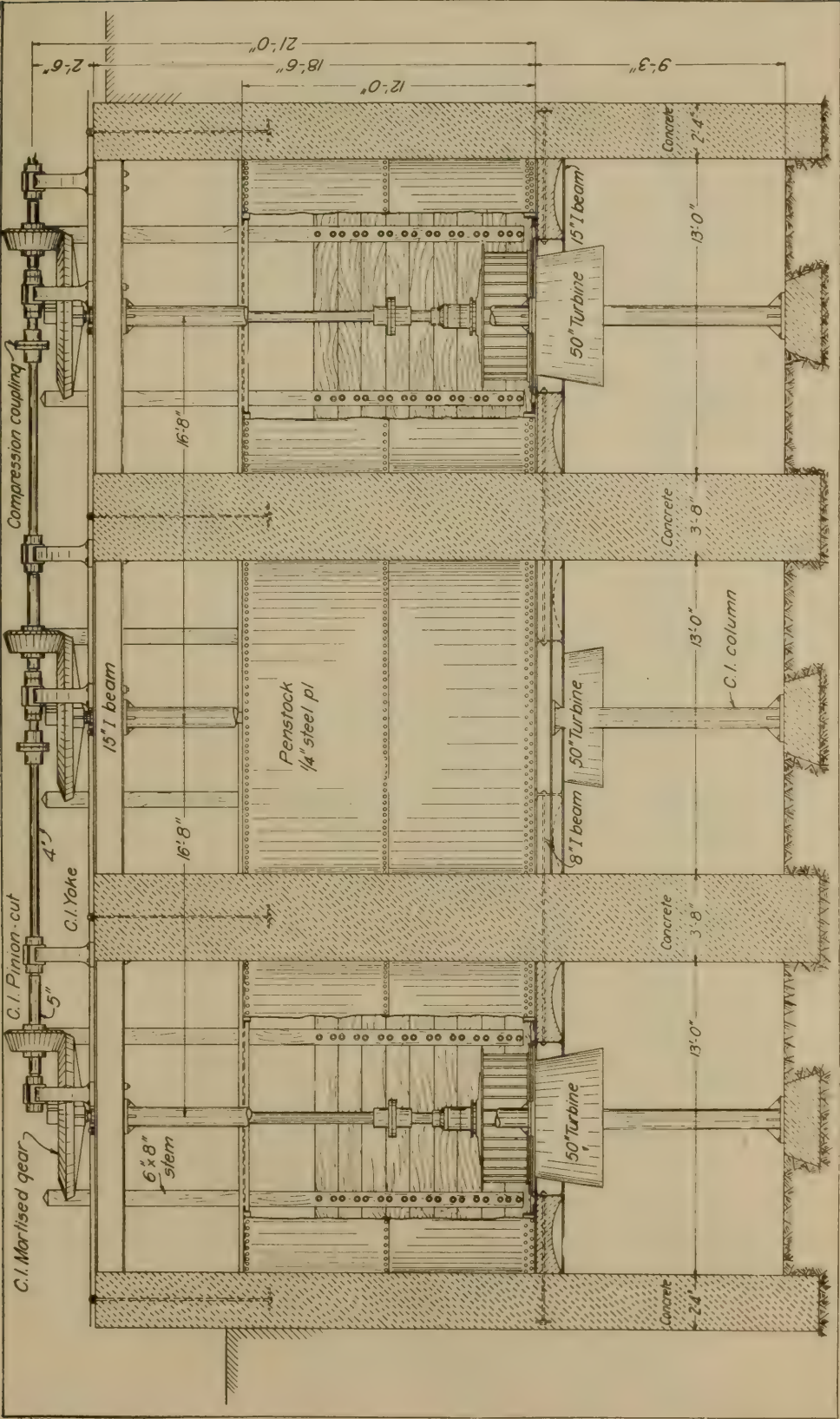


Fig. 27.—Vertical Turbine Setting—Downstream Elevation.

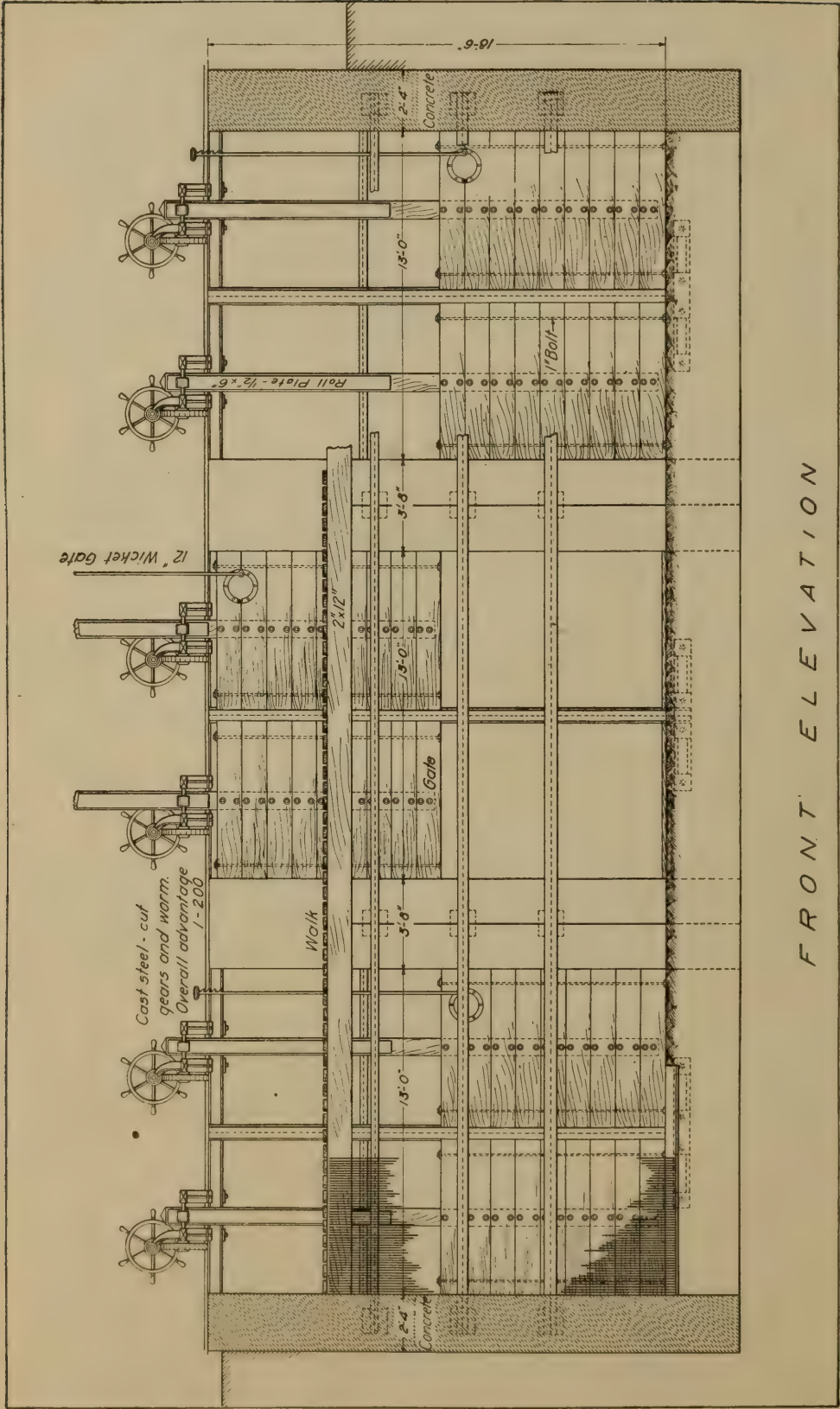


Fig. 28.—Timber Penstock Gates.

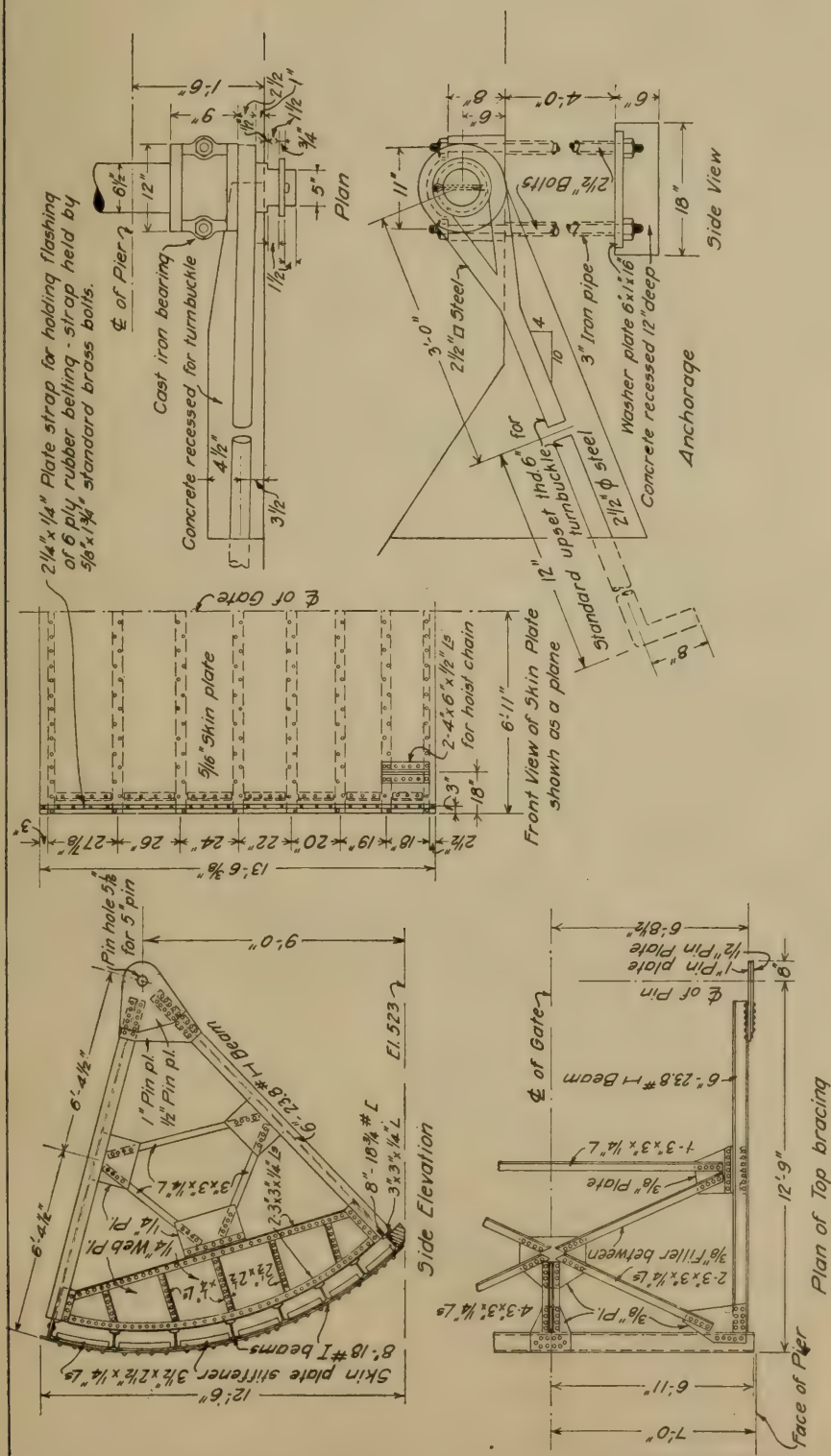


Fig. 29.—Steel Tainter Gate and Anchorage.

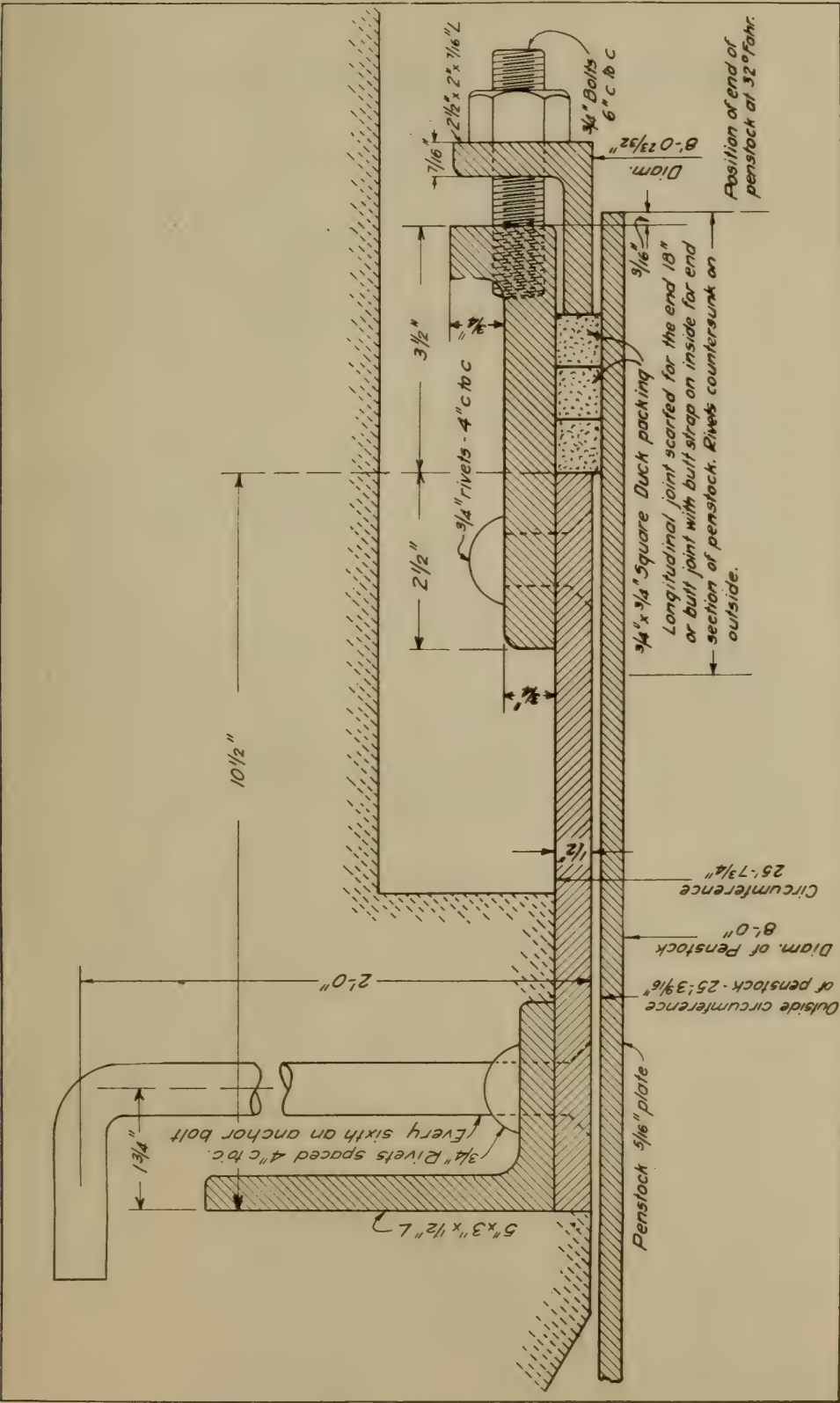


Fig. 31.—Expansion Joint for Plate Steel Penstock.

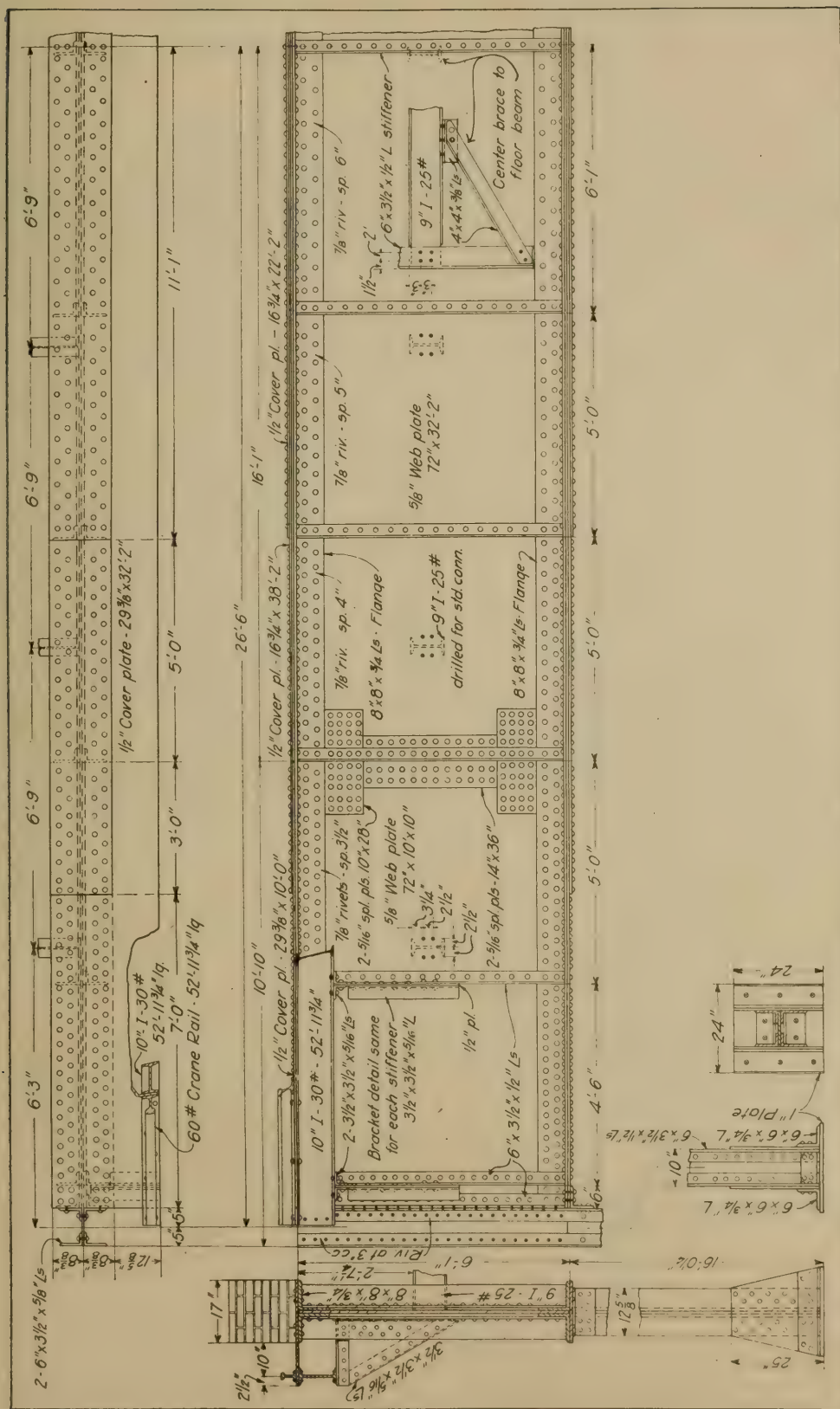


Fig. 33.—Structural Steel Plate Girder Carrying a Crane Rail and Supporting a Brick Wall Over Switchboard Gallery.

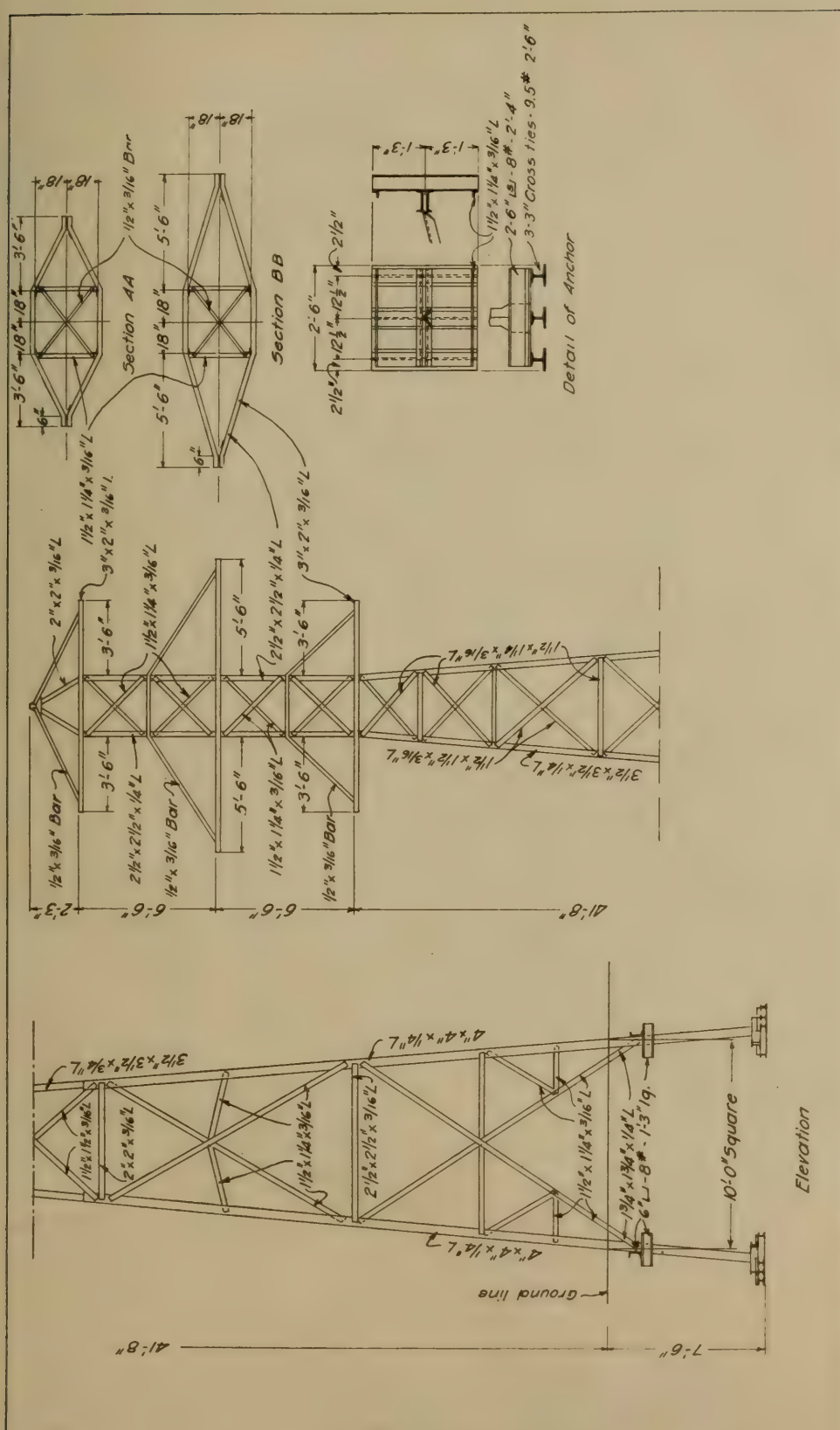


Fig. 35.—Structural Steel Transmission Line Tower—Excavation, Work and Material for Setting Anchors and for Construction and Erection of Tower.

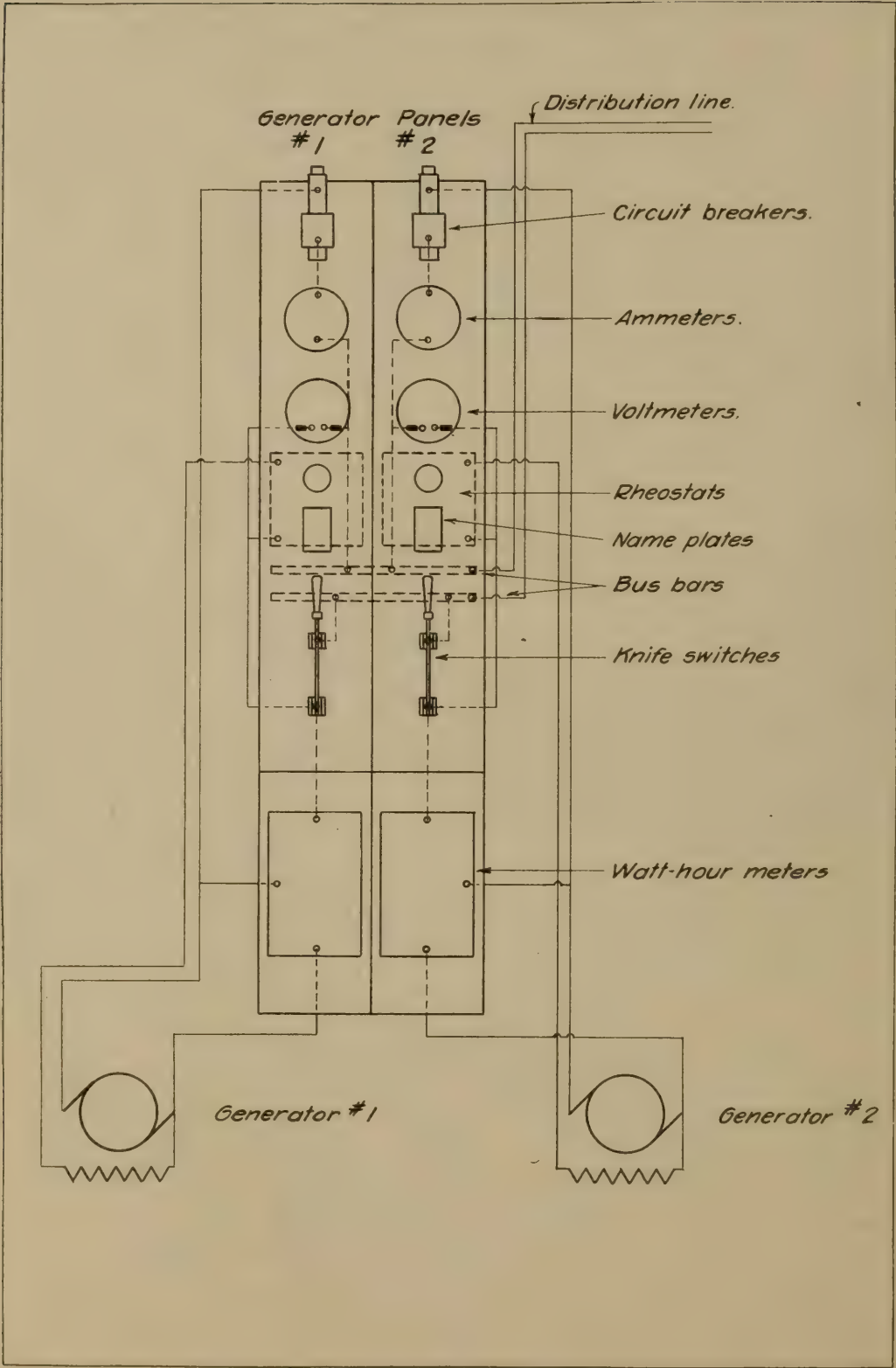


Fig. 36.—Switch Board for Two 500 K. W. Direct Current Generators—Furnishing and Erecting.

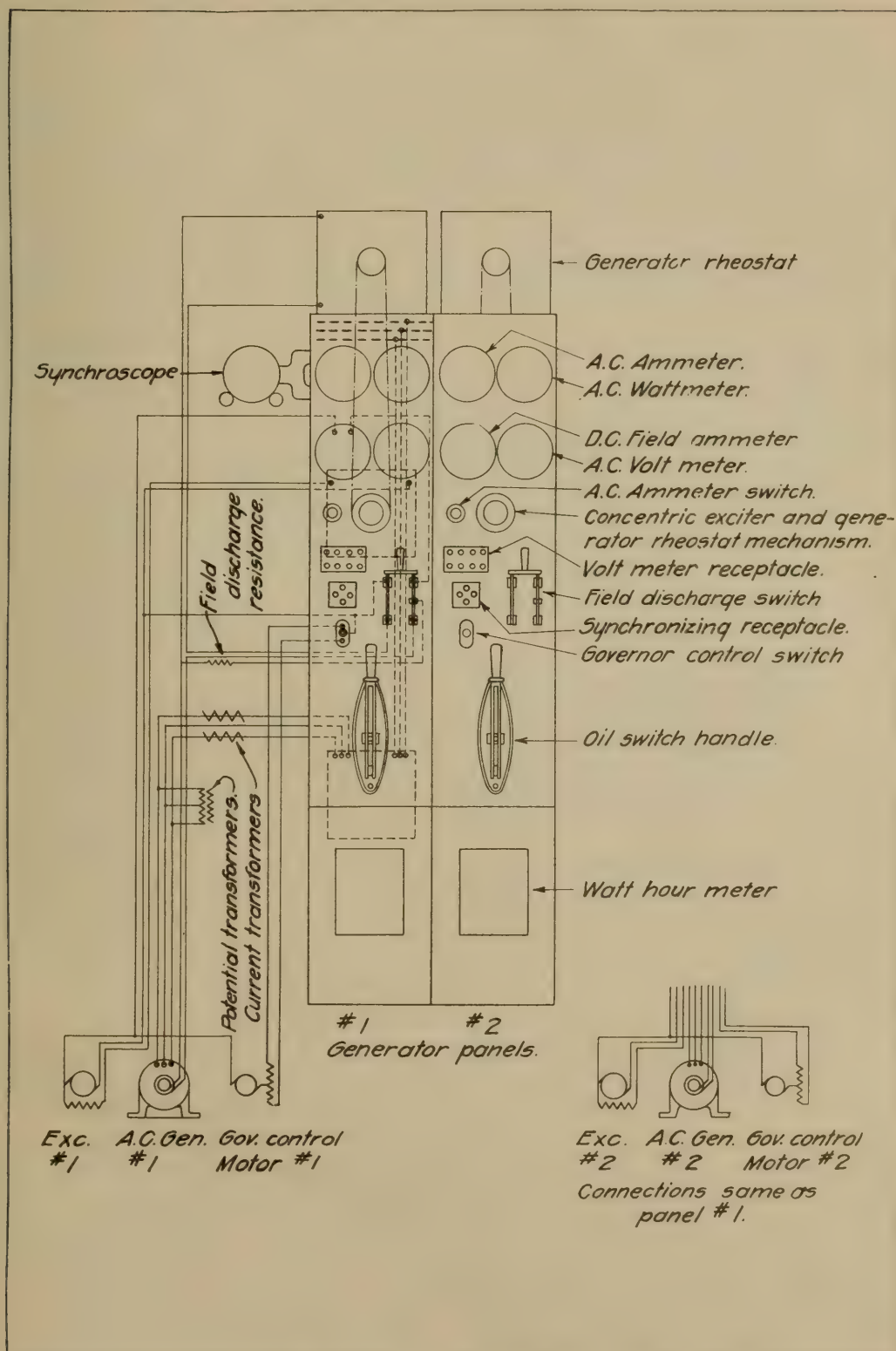


Fig. 37.—Switch Board for Two 500 K. W. Alternating Current Generators—
Furnishing and Erecting.

APPENDIX D

BIBLIOGRAPHY OF SPECIFICATIONS

In compiling this bibliography the following references were consulted:

	Abbreviation
Engineering News.....	Eng. News
Engineering Record.....	Eng. Rec.
Engineering Contracting.....	Eng. Cont.
Transactions American Society of Civil Engineers.....	A. S. C. E.
Transactions American Society of Mechanical Engineers.....	A. S. M. E.
Transactions American Institute of Electrical Engineers.....	A. I. E. E.
General Sessions National Electric Light Association.....	N. E. L. A.
Proceedings American Society for Testing Materials..	Am. Soc. Test. Mat.
Proceedings American Water Works Association....	Am. W. Wks. Ass'n
Proceedings American Railway Engineering and Maintenance of Way Association.....	A. R. E. & M. W. Ass'n
Proceedings New England Water Works Association..	N. E. W. Wks. Ass'n
A Manual of Engineering Specifications and Contracts, by Lewis M. Haupt (1883). Published by J. M. Stoddard & Co., Philadelphia	
.....	Haupt
Engineering Contracts and Specifications, by J. B. Johnson, McGraw-Hill Book Co., New York	
.....	Johnson
Standard Specifications, by John C. Ostrup. Published by McGraw-Hill Book Co., New York.....	
.....	Ostrup
References to several other publications are given, among which may be noted:	
Transactions of the Society of Automobile Engineers	
Proceedings Master Car Builders' Association	
Professional Papers, Corps of Engineers, United States Army	
Proceedings of National Association of Cement Users	
Proceedings of American Railway Bridge and Building Association	

Reference to The Engineering News and Engineering Record are usually given as follows: 1913-II-672—the first number referring to the year, the second indicating the volume of that year and the last giving the page on which the matter is found. It should be noted that references in periodicals given as taken from the proceedings of the American Society for Testing Materials or given in any volume of the publications of that society may be found in their latest form in the latest Year Book of the Society.

STANDARD SPECIFICATIONS

The following specifications have been proposed by various individuals and organizations as "standard," and if found satisfactory for particular purposes may be adopted by reference or reproduced with necessary changes. Frequently revised editions may be available, and in any case when their use is contemplated, copies of the latest edition should be secured, examined, and if satisfactory, filed for reference after adoption for any special purpose.

Alloys—

Aluminum alloys, copper alloys, phosphor bronze, brass, babbit, etc.

Trans. Society Automobile Engineers, 1910, 1911.

Manganese bronze ingots. Proc. Am. Soc. Test. Mat., 1911. See "Alloys."

Aluminum—

Castings, wire and cable. Year Book Am. Soc. Test. Mat., 1910. See "Aluminum."

Boilers—

Report Am. Boiler Mfgs. Ass'n. Steam Engineering, June. 1900. See "Boilers."

Brick—

Proc. Am. Soc. Test. Mat., 1913. See "Pavement," "Brick," Etc.

Bridges—

Ostrup. Proc. A. R. E. & M. W. Ass'n, 1906, 1907, 1905, 1910. See "Bridge," "Timber," "Iron and Steel."

Buildings—

Jour. Am. Soc. Eng. Cont., 1911. Handbook for Architects and Builders. Vol. 16, 1913. See "Building," "Fire Protection."

Castings—

Gray iron. Proc. Am. Soc. Test. Mat., 1905. Trans. Soc. Auto. Eng'rs, 1910, Am. Foundry Men's Ass'n, 1901.

Steel. Proc. Am. Soc. Test. Mat., 1905. Trans. Soc. Auto Eng'rs, 1910. See "Aluminum," "Iron and Steel," "Cars."

Cement—

U. S. Standard. Eng. News, 1896, 1897, 1898. Proc. Am. Soc. Test. Mat., 1909. Proc. A. R. E. & M. W. Ass'n, 1903, 1905, 1909. Trans. Am. Soc. C. E., 1910. Professional Paper 28, Corps of Eng'rs. U. S. Army. Eng. Rec. 1910-I-819. Trans. Can. Soc. C. E. Vol. 23. See "Cement."

Concrete—

Proc. Nat. Ass'n Cement Users, 1908. Engineering Work in Towns and Cities, by McCullough. Ostrup. Proc. A. R. E. & M. W. Ass'n, 1910. See "Concrete."

Copper—

Proc. Am. Soc. Test. Mat., 1911 and 1913. See "Copper," "Wire," Etc.

Electrical—

Rules. Trans. A. I. E. E., 1911.

Motors. Trans. A. I. E. E., 1907.

Insulators. Trans. A. I. E. E. 1914.

Lights. Eng. Rec., 1913. Trans. Soc. Auto. Eng'rs, 1911.

Transformers. "Electrical Machine Design," by Gray. See "Electrical,"
"Transmission Lines."

Excavation—

Seattle. Eng. Cont. July 5, 1911. See "Excavation," "Measurement."

Fences—

A. R. E. & M. W. Ass'n. 1911.

Fire Protection—

National Fire Protection Ass'n,* 87 Milk Street, Boston. Nat'l Board
Fire Underwriters,* 135 William Street, New York.

Building—

Fireproof Construction Requirements. National Fire Protection Assoc.
Nat'l Board Fire Underwriters.

Building Code. Concrete Construction. Nat'l Board Fire Underwriters.

Recommendations pertaining to Slow Burning or Mill Construction.
Nat'l Board of Fire Underwriters.

Pumps—

Centrifugal, Electric, Rotary and Steam Fire Pumps. Nat'l Board of Fire
Underwriters, Notes on Hydraulics by I. J. Owen. Pub. by The Insur-
ance Press, New York, Crosby-Fiske Handbook of Fire Protection.
Pub. by Insurance Field Co., Louisville, Ky

Sprinklers—

Rules and Requirements for Automatic Sprinkler Systems. Nat'l Board
Fire Underwriters.

Tanks—

Pressure and Gravity. Nat'l Board of Fire Underwriters.

Wiring—

Insulation. Nat'l Bd. Fire Underwriters.

Hydrants—

Jour. N. E. W. Wks. Ass'n, 1912. Eng. News, Aug. 7, 1913, June, 1913.
See "Hydrants," "Valves."

Iron and Steel—

Axles. Proc. Am. Soc. Test. Mat., 1905, 1911, 1913.

Boiler Plate, rivet steel. Trans. A. S. M. E. 1902, 1903, 1904, 1914. Proc.
Am. Soc. Test. Mat., 1909, 1913.

Blooms and Billets. Am. Soc. Test. Mat., 1913.

Castings. Proc. Am. Soc. Test. Mat., 1904, 1905. Trans. Soc. Auto.
Eng'rs, 1910.

Malleable Iron. Trans. Soc. Auto Eng'rs, 1910.

Pig Iron. Proc. Am. Soc. Test. Mat., 1909.

* Copies of publications of the above associations may be secured from
the secretaries at the addresses given.

Iron and Steel—Continued.

- Rails.* Carnegie Steel Co. Pamphlet. Proc. Am. Soc. Test. Mat., 1906, 1907, 1909, 1915. "Steel Rails" by Sellew.
- Reinforcing Bars.* A. R. E. & M. W. Ass'n, 1910. Trans. A. S. C. E., 1910. Proc. Am. Soc. Test. Mat., 1911, 1912, 1913.
- Splice Bars and Stay Bolts.*—Proc. Am. Soc. Test. Mat., 1907, 1909, 1913. Carnegie Steel Co. Handbook.
- Spring Steel.* Proc. Am. Soc. Test. Mat., 1907.
- Structural.* Proc. Am. Soc. Test. Mat., 1909. Ostrup. Trans. Soc. Auto Eng'rs, 1910. See "Iron and Steel," "Castings," "Railways."

Masonry—

- Stone.* Proc. A. R. E. & M. W. Ass'n. Vol. 9 and Year Book 1911. See "Masonry."

Measurement—

- Concrete.* Nat'l Ass'n. Cement Users. Eng. News, Vol. 67. See "Measurement."

Oils—

- Coal Tar Creosote.* A. R. E. & M. W. Ass'n, 1910.
- Linseed.* Proc. Am. Soc. Test. Mat., 1913.
- Lubricating.* Trans. Soc. Auto Eng'rs, 1910. See "Oils."

Paint—

- Preservative Coatings.* Proc. Am. Soc. Test. Mat., 1913. Trans. Soc. Auto Eng'rs, 1911. See "Paint."

Pavements—

- Street Railway Pavements.* Nat'l Paving Brick Mfgs. Ass'n, 1911. Assoc. for Standardizing Paving Specifications. Annual Reports. *Chicago.* Eng. Cont. Mar. 9-16, 1910. *Maine.* Eng. Cont. Sept. 16, 1914. *Pittsburg.* Eng. Cont. Aug. 21, 1912. *Seattle.* Eng. Cont. Aug. 9, 1911.
- Asphalt.* *New Jersey.* Eng. Rec., 1912. *New York City* "Highway Engineering," by Morrison. American Soc. Municipal Imp., 1911. Pub. by Municipal Journal, Chicago. Eng. Cont. Mar. 23, 1910.
- Brick.* *Chicago.* Eng. News, 1910. Nat'l Pav. Brick Mfgs. Ass'n. W. P. Blair, Sec'y. *Cleveland, Ohio.* Proc. Am. Soc. Mun. Imprvt., 1911. Pub. by Municipal Jour. Year book Am. Soc. Test. Mat., 1913.
- Concrete.* Nat'l Ass'n Cement Users. Eng. Cont. Jan. 20, 1909.
- Macadam.* *Chicago.* Eng. News, 1910. *New Jersey* "Highway Engineering" by Morrison. See "Pavement and Road Construction," "Brick," Etc.

Plastering—

- Standard Specifications for Exterior Plastering (stucco). Assoc. Metal Lath Mfgs. Pamphlet. August, 1913. 812 Wick Bldg., Youngstown, Ohio.

Pipe—

- Cast Iron.* Proc. Am. W. Wks. Ass'n, 1908, 1912. Proc. Am. Soc. Test. Mat., 1904. *Seattle.* Eng. Cont. Aug. 2, 1911.
- Concrete.* Proc. Nat. Ass'n Cement Users, 1911.
- Vitrified.* Am. Soc. Test. Mat., 1914. Eng. Cont. Aug. 19, 1914. *Iowa State Drain. Ass'n,* Eng. News, 1913.

Pipe—Continued.

Wood Stave. Proc. Am. Ry. Bridge & Bldg. Ass'n. 32d Ann. Rept. See "Pipe."

Railways—

Ballast. Proc. A. R. E. & M. W. Ass'n, 1902, 1905, 1910.

Car Wheels. Proc. Am. Soc. Test. Mat., 1905, 1913.

Cars. Proc. Master Car Bldrs. Ass'n, 1911.

Fences. A. R. E. & M. W. Ass'n, 1911.

Frogs and Switches. A. R. E. & M. W. Ass'n, 1909, 1910.

Rails. See "Iron and Steel."

Rolling Stock. Proc. Am. Soc. Test. Mat. 1904.

Signals. A. R. E. & M. W. Ass'n, 1905-6-7.

Tires. Proc. Am. Soc. Test. Mat., 1909.

Track Construction. Eng. News, 1900-II, p. 430. See "Railways," "Cars," "Iron and Steel," Etc.

Refractory Material—

Silica Brick, Etc. Can. Engr. Vol. 23, p. 331.

Sewers—

American Soc. Mun. Impvt. Munic. Engng., 1912.

Sidewalks, Curbs and Gutters—

Nat'l Ass'n Cement Users. Eng. News, 1909. Eng. Cont. Jan. 20, 1909, Feb. 23, 1910. "Civil Eng. Pocket Book," by Frye. "Engineering Work in Towns and Cities," by McCullough. See "Sewers." Nat'l Ass'n Cement Users. Eng. Cont. Jan. 20, 1911. Civil Engrs. Pocket Book, Frye. Engineering work in Towns and Cities. McCullough. See "Sidewalk."

Signals—

A. R. E. & M. W. Ass'n, 1905-6-7. See "Railways."

Timber—

Structural. Proc. Am. Soc. Test. Mat., 1907, 1910, 1913. Seattle. Eng. Cont. Aug. 30, 1911. Trans. A. R. E. & M. W. Ass'n, 1908-9-13. Year Book A. R. E. & M. W. Ass'n, 1911. Ostrup. Yellow Pine Mfgs. Ass'n. Manual of Standard Construction, 1911.

Ties. Eng. News, 1911-II. p. 430 A. R. E. & M. W. Ass'n, 1906. See "Timber."

Transmission Line—

Overhead Wires—Seattle. Eng. News, Vol. 67. Nat'l Elec. Lt. Ass'n, 1913. See "Transmission Line," "Wire," "Cable."

Valves—See "Hydrants."**Wire—**

Copper. Harddrawn. Proc. Am. Soc. Test. Mat., 1909.

Aluminum. Year Book. Am. Soc. Test. Mat., 1910.

Insulated. Proc. A. I. E. E., 1911. Proc. Ry. Signal Ass'n, Vol. 8.

Bonding. Copper Clad. Proc. Ry. Signal Ass'n, Vol. 9. See "Wire."

Wiring. See "Fire Protection."

Zinc. Penn. R. R. Soc. Auto Engrs. Vol. 6. Proc. Am. Soc. Test. Mat., 1911.

SPECIFICATIONS ALPHABETICALLY ARRANGED

Acetylene Generators—

Specifications for acetylene generators at Fort McPherson, Ga. Eng. News, 1904-I-102.

Aeroplane—see "Flying Machine."**Air Brake Hose—**

Discussion at Master Car Builders' Ass'n. Eng. News, 1901-II-7; 1904-I-586; 1904-II-9.

Air Compressor—

Air compressor for air lift plant at Spring Lake, N. J. Eng. News, 1905-I-223.

Alloys—

Specifications for Aluminum Alloys, by Henry Souther, Chm. Standards Comm. for Soc. of Automobile Engineers, 1910. Reference: Trans. of the Soc. of Automobile Engineers, Vol. 5, pp. 168-175. Note: For notes and instructions referring to above, see same volume, pp. 176-202.

Copper and its alloys. Abstract of Pennsylvania R. R. specifications for materials. (In practical use for several years. Reprint rec. by Soc. of Automobile Engineers' Standard Committee, 1911.) Reference: Trans. of the Soc. of Automobile Engineers, Vol. 6, pp. 400-445.

Specifications for Phosphor-Bronze Bearing Metal, by Henry Souther, Chm. Standards Comm. for Soc. of Automobile Engineers, 1910. Reference: Trans. of the Soc. of Automobile Engineers, Vol. 5, pp. 168-175. Note: For notes and instructions referring to above, see same volume, pp. 176-202.

Yellow Brass, by Henry Souther, Chm. Standards Comm. for Soc. of Automobile Engineers, 1910. Reference: Trans. of the Soc. of Automobile Engineers, Vol. 5, pp. 168-175. Note: For notes and instructions referring to above, see same volume, pp. 176-202.

Valve Bronze, by Henry Souther, Chm. Standards Comm. for Soc. of Automobile Engineers, 1910. Reference: Trans. of the Soc. of Automobile Engineers, Vol. 5, pp. 168-175. Note: For notes and instructions referring to above, see same volume, pp. 176-202.

Babbitt Metal, by Henry Souther, Chm. Standards Comm. for Soc. of Automobile Engineers, 1910. Reference: Trans. of the Soc. of Automobile Engineers, Vol. 5, pp. 168-175. Note: For notes and instructions referring to above, see same volume, pp. 176-202.

Standard specifications for manganese bronze ingots (adopted 1911). Proc. Am. Soc. Test. Mat., 1911, Vol. 11, p. 150.

Aluminum—

Wire for Electric Transmission Lines, by F. A. C. Perrine and F. G. Baum. Eng. News, 1900-II-215.

Castings, wire and cable. Am. Soc. Test. Mat. Year Book, 1910.

Asphalt—see "Bitumen."

Axles—see "Iron and Steel."

Ballast, Railway—

Specifications. Report A. R. E. & M. W. Ass'n. Eng. News, 1903-I-285.

Standards in United States, Canada and Mexico. Eng. News, 1900-II-142.

Roadbed ballast. Report of committee, materials and form of cross-section. Proc. A. R. E. & M. W. Ass'n, 1902, Vol. 3, p. 128.

Ballasting. Report of committee specifications for materials and cross-section for stone, gravel, cinders, burnt clay, shells. Proc. A. R. E. & M. W. Ass'n, 1905, Vol. 6, p. 734; 1906, Vol. 7, p. 83.

Revised—for ballast specifications. Proc. A. R. E. & M. W. Ass'n, 1910, Vol. 11, p. 907.

Balloon—

U. S. Signal Corps. Specifications for a dirigible balloon. Trans. A. S. M. E., 1908, Vol. 30, p. 689.

Barges—

Specifications for steel barges for Mississippi River improvement work. Eng. Cont., Apr. 24, 1912, p. 457.

Bearings—see "Iron and Steel;" "Alloys."

Belts—

Leather driving belts. Water power electric plant at Austin, Texas. Johnson, p. 245.

Bitumen—

Confusion of Terms "Asphalt" and "Pitch" in Specifications, by C. G. Atwater. Eng. News, 1908-I-639.

Asphaltic pavements and sheet asphalt at Vancouver, B. C. Eng. News, 1912-II-770.

Methods of analysis for tars and suggested specifications for their use. U. S. Office of Public Roads. Eng. Cont., Oct. 14, 1908, p. 240.

Specifications for bituminous road binders. Paper before First Congress of Road Builders, by A. B. Fletcher. Eng. Cont., Sept. 1, 1909, p. 185.

Specifications of New York State Highway Department for Bituminous Macadam and Bituminous Materials. Eng. Cont., Dec. 8, 1909, p. 490.

Asphalt specifications of Pennsylvania Highway Department. Eng. Cont., Aug. 19, 1914, p. 193.

See also "Pavements," "Oils."

Toronto Asphalt Specifications by G. C. Powell. Can. Eng. Vol. 25, p. 837.

Bituminous Concrete Plant—

English Specifications for Bituminous Concrete Mixing Plant and Description of Acceptance Test, by W. H. Grieves. Eng. Cont., Sept. 30, 1914, p. 325.

Boilers—

- United States government naval specifications. Eng. News, 1899-I-15, 183.
- Specifications for water tube boilers for St. Louis, Mo. Eng. News, 1894-I-151; 1896-II-280, 315, 330.
- Standard specifications. Report to the American Boiler Manufacturers' Association. Eng. News, 1898-II-251.
- Uniformity in specifications for marine boilers. Report to the Am. Boiler Manufacturers' Association. Eng. News, 1904-II-373.
- Specifications for horizontal tubular and boiler equipment. Dummy form. Useful in making up specifications for tubular boilers together with settings. Power, Dec., 1905, pp. 728, 729.
- Specifications for boilers. Fairly complete, carefully drawn up in blank form, convenient for general use. The Engineer, July 15, 1902, pp. 514, 515.
- Uniform specifications for boilers. Recommendations of the Amer. Boiler Makers' Ass'n Comm. Contains some of the important features of report. Very practical. Modern machinery, 1900-1901, pp. 233-236.
- Specifications for boilers. Standard requirements of the Amer. Boiler Manufacturers' Ass'n. Of practical interest and value. Includes items of greatest value to those who are engaged in operating plants, but has nothing to do with manufacturing of boilers. Steam Engineering, June, 1900, pp. 317, 318.
- Boilers. New Orleans, La. Johnson, p. 409.
- Water tubular boilers and settings. St. Louis, Mo. Johnson, p. 296.
- See also "Steam Plant."

Brick—

- Specifications for brick. Report to the Am. Soc. Test. Mat. Eng. News, 1909-II-56.
- Specifications for Common and Vitrified Brick and Laying Same in St. Louis, Mo., by W. W. Horner. Eng. Cont., Sept. 13, 1911, p. 286.
- Proposed standard specifications for building and paving brick. Proc. Am. Soc. Test. Mat., Vol. 13, 1913, p. 286.
- See also "Pavement."

Bridge—General and Details—

- Specifications for the Design of Bridges and Subways, by H. B. Seaman. Covers, loading, stresses, details, foundations, etc. Trans. A. S. C. E., Vol. 75, 1912, p. 313.
- Standard Specifications for Bridges, by Ostrup. (McGraw-Hill Book Company.) Highway Bridges, pp. 13-25; Railroad Bridges, pp. 26-36; Plate Girders, pp. 37-42. Note: Adapted from General Specifications for Steel Railroad Bridges, 1910, of A. R. E. & M. W. Ass'n.
- Materials and Workmanship. Materials for Structural and Rivet Steel, by Ostrup. Pages 43-53.
- Inspection, Painting and Erection, Standard Specifications for, by Ostrup. Pages 54-57.

Bridge—General and Details—Continued.

Specifications and tables for steel framed structures. Publication by American Bridge Co. of New York. General edition, 1913.

Bridge—Highway—

Relation of Bridge Specifications to Highway Improvement. Paper before Ind. Eng. Soc., by Prof. A. Smith. Eng. Rec., 1911-I-83.

Highway bridge specifications outlined by U. S. office of public roads. Eng. Rec., 1913-II-230. U. S. Dept. Agriculture Office of Public Roads Circular 100, 1913.

Steel highway bridge. Specifications of the office of public roads. Editorial Eng. Rec., 1913-II-255.

Steel highway bridges and viaducts. American Bridge Company. Johnson, p. 433.

Bridges. Specifications for the superstructure of the Blackwell's Island bridge. Lengthy abstract carefully drawn up. Contain special features. Eng. Rec., Vol. 48, Aug. 22, 1903, pp. 222-224.

Bridge, specifications for a suspension. Full specifications drawn up by Mr. Cooper for suspension bridge over Hudson River at New York City. Eng. News, Vol. 33, Mar. 7, 1895, pp. 159, 160.

Specifications for concrete floor by United States Office of Public Roads. Eng. Rec., 1913-II-305.

Specifications for Replacing Wood Floor with Reinforced Concrete for Highway Bridges, by L. C. Smith. Eng. Cont., Feb. 14, 1912, p. 179.

General specifications for concrete and steel bridge work of the Ill. State Highway Commission. Eng. Cont., Oct. 21, 1914, p. 391.

Design features of Williams' reinforced concrete highway bridge, Columbus, Ohio. Specifications for work and materials. Eng. Cont., June 3, 1914, pp. 309, 643.

See also "Concrete."

Bridges, Metal, Railway—

Bridge specifications of the Baltimore and Ohio R. R. Eng. News, 1894-I-408; 1895-II-365; 1896-I-392.

Bridge specifications of the Boston & Maine Ry. Eng. News, 1897-I-175.

Specifications for Chicago Drainage Canal railway bridges. Eng. News, 1897-II-363.

Specifications for steel for railway bridges. Drawn up by Geo. H. Thompson, formerly bridge engineer of New York Central R. R., cover difficulties in the way of obtaining suitable materials at reasonable cost. Eng. News, May 31, 1894, p. 446.

Specifications for bridge over the Mississippi river at Rock Island, Ill. Eng. News, 1896-I-407.

Specifications for suspension bridge over North river, New York. Eng. News, 1895-I-145, 159, 176.

Specifications for steel bridges and viaducts of the Atchison, Topeka & Santa Fe Ry. Eng. News, 1903-I-485.

Specifications for Blackwell's Island bridge, New York. Eng. News, 1903-II-113, 202, 442.

Bridges, Metal, Railway—Continued.

Specifications for material and workmanship for steel structures and schedule of unit strains. Report of committee. A. R. E. & M. W. Ass'n, 1903, Vol. 4, p. 130.

Specifications for Erection of R. R. Bridges, by J. E. Greiner. A. R. E. & M. W. Ass'n, 1910, Vol. 11, p. 130. Also Eng. Cont., Mar. 30, 1910, p. 299.

General specifications for steel railroad bridges, loads, design details and material. Report of committee. A. R. E. & M. W. Ass'n, 1905, Vol. 6, p. 218; 1906, Vol. 7, p. 185; 1910, Vol. 11, p. 115.

Steel Railroad Bridges and Viaducts. Pennsylvania Railroad, Johnson, p. 459.

American Bridge Co.'s New Specifications for Bridges. Article contains important extracts from same, selected to cover problems of design. Eng. Rec., Vol. 42, Dec. 1, 1900, pp. 521-523.

Specifications for Steel Bridges by J. A. L. Waddell. John Wiley & Sons, 1900. See also De Pontibus, by Waddell. John Wiley & Sons, 1898.

Specifications for river bridge. Ohio river. Haupt, p. 179.

Specifications for wrought iron railroad bridge. Pennsylvania R. R., Morrisville Station. Joseph M. Wilson, Engineer Bridges. Haupt, p. 142.

Specified and Actual Loads of Railway Bridges. Eng. Rec., Vol. 66, p. 622.

Specifications for East River bridge, New York. Eng. News, 1901-I-290, 454; Eng. Rec., 1899-II-573.

Specifications for electric railway bridges of the Massachusetts Board of Railroad commissioners. Eng. News, 1900-II-427.

Sydney Harbor bridge, requirements for stresses and materials. Eng. News, 1901-II-58.

Specifications for workmanship, Thebes bridge. Eng. News, 1905-I-481.

Specifications for steel railroad bridges. Trans. A. S. C. E., Vol. 41, 1899, pp. 140, 164, 257.

Specifications for Metal Bridges Movable in a Vertical Plane. B. R. Leffler, with discussion. Trans. A. S. C. E., Vol. 76, 1913, p. 370.

See also "Iron and Steel;" "Cable."

Bridge, Timber—

Specifications for timber bridge. Eng. News, 1901-I-264.

Recommended specifications for workmanship for pile and timber trestles. Committee Report. A. R. E. & M. W. Ass'n, 1906, Vol. 7, p. 689, 1907, Vol. 8, p. 398.

Discussion of specifications for wooden bridges and trestles. A. R. E. & M. W. Ass'n, 1902, Vol. 3, p. 238.

Specifications for timber bridges and trestles. Committee Report. A. R. E. & M. W. Ass'n, 1905, Vol. 6, p. 27.

Bridge, Timber—Continued.

Specifications for metallic details used in wooden bridges and trestles. Committee Report. A. R. E. & M. W. Ass'n, 1906, Vol. 7, p. 692; 1910, Vol. 11, p. 178.

Bridge and Trestle Work. Haupt, p. 173.

See also "Timber."

Bronze—see "Alloys."**Building—**

Architects' and builders' uniform contract. (Adopted and recommended for general use by American Inst. of Architects; also the National Association of Builders.) Reference: Electric Lighting Specifications, by Merrill; 2d edition, pp. 204–213.

Building code of the City of New York theaters and opera houses: (Proposed by Joint Comm. of A. I. of Architects, Nat'l Board of Fire Underwriters, etc.) Reference: Insurance Engineering, Vol. 21, pp. 298–307. Note: For various rules, regulations and recommendations of Nat'l Board of Fire Underwriters, Nat'l Fire Protection Ass'n, see late volumes of Fire Insurance.

Specifications for oil houses. (Adopted by Independence Inspection Bureau of Philadelphia.) Reference: Insurance Engineering, Vol. 21, p. 444.

Municipal building laws in the United States. Compared by R. Fleming, Designing Engineer of American Bridge Company. Eng. News, 1913-II-9.

Various rules and requirements of the National Board of Fire Underwriters for different forms of building construction and fire protection, pumps, appliances, etc. Reference: Handbook of Fire Protection for Improved Risks, by Crosby & Fiske. Press of Standard Pub. Co., Boston, Mass.

Building ordinance of the City of Chicago. (Passed by the city council, Dec. 5, 1910.) Reference: Handbook for Architects and Builders, published under auspices of Chicago Architects Business Association. Vol. 16, 1913, p. 67.

Complete specifications for a frame dwelling. "International Library of Technology," Vol. 33, sect. 23, p. 1.

Report on Uniform Specifications for Buildings, by Wm. B. Bamford. Discusses the general considerations affecting contract specifications. Journal Am. Soc. of Eng. Cont., March, 1911.

Specifications for Office Buildings, by Fred W. Winterbum. Suggestions helpful in writing a good specification. Brick Builder, Dec. 1909, Vol. 18, pp. 257–259.

High service pumping station No. 3, St. Louis, Mo. Johnson, p. 267. Engine house, St. Louis Water Works. Johnson, p. 304.

Passenger depot. Baltimore & Potomac R. R., Washington, Haupt, p. 124.

Construction of college building. Pennsylvania, Haupt, p. 110.

Building—Continued.

Chicago specifications for standard hollow tile fire proofing. Reference: Handbook for Architects and Builders, Vol. 16, 1913, p. 183.

Gravel roofing specifications. (Adopted by Chicago Master Composition Roofers' Ass'n.) Reference: Handbook for Architects and Builders, Vol. 16, 1913, p. 302.

Modern plumbing specifications used on work done under the supervising architect of the treasury department, Washington, D. C. The Building Mechanics' Ready Reference, by Richey (Plumbers, Steam Fitters' and Tinnners' Edition), pp. 428-450.

Specifications for the plumbing installation in the Hotel Santiago, Havana, Cuba. Plumbing Plans and Specifications, by J. J. Cosgrove, pp. 65-84.

World's Fair (Chicago) for materials and workmanship. Eng. News, 1892-I-291.

Cleveland, O., regulations and specifications for reinforced concrete. Eng. News, 1912-I-99, 305.

Specifications for structural work of buildings. Trans. A. S. C. E., 1905, Vol. 51, p. 371.

Specifications for Grade A. Office Building. Requirements of Nat'l Fire Proofing Ass'n. Eng. Rec. Vol. 73, p. 831.

Also see "Lathing;" "Roofing;" "Masonry." etc.

Cable, Suspension—

Specifications for suspension cable. Drawn up by Mr. L. L. Buck for new East River bridge. Extracts cover manufacture and erection of wire work proper. Eng. Rec., Vol. 40, Nov. 18, 1899, pp. 573, 574.

See also "Transmission Line."

Caissons—

Specification for caisson for pier of Cincinnati highway bridge. Trans. A. S. C. E., 1892, Vol. 27, p. 218.

Canal Locks—

Cut stone masonry at Sault Ste. Marie. Eng. News, 1895-II-194-238. Also see "Masonry;" "Concrete."

Cars—

Proposed specifications for car couplers. Eng. News, 1892-I-436; 1899-I-393-396.

Couplers for interurban cars where interchange of equipment is involved. Eng. News, 1912-II-861.

Specifications and guarantee for C. I. wheels. Rept. M. C. B. Ass'n. Eng. News, 1897-I-360, 367.

Cast iron wheels for sixty, eighty and one hundred thousand pound cars. Eng. News, 1904-I-614; 1904-II-9.

Specifications for C. I. wheels adopted by Master Car Builders' Ass'n. Eng. News, 1909-II-112.

Specifications adopted by Am. Soc. Test. Mat. Eng. News, 1912-I-659.

Cars—Continued.

Standard specifications for C. I. car wheels. Proc. Am. Soc. Test. Mat., Vol. 5, 1905, p. 65.

Proposed standard specifications for forged and rolled, forged, or rolled solid steel wheels for engine truck, tender and passenger subway and elevated Ry. service. Proc. Am. Soc. Test. Mat., Vol. 11, 1911, p. 55.

Same for freight service. Same, p. 59.

Gondola cars. Empire Transportation Company, Haupt, p. 201.

Butter and egg cars. Empire Transportation Company, Haupt, p. 198.

Stock cars. Empire Transportation Company, Haupt, p. 197.

Rack cars. Empire Transportation Company, Haupt, p. 194.

Box cars. Empire Transportation Company, Haupt, p. 192.

Boiler tank cars. Empire Transportation Company, Haupt, p. 188.

Car materials. Standards and recommended practice of the Master Car Builders' Association. Proceedings Master Car Builders' Ass'n, Vol. 45, 1911, pp. 521-788. Includes various specifications for car material and equipment. Standard specifications, recommended practice.

Castings—

Specifications for malleable castings (C. L. Sullivan). Eng. News, 1897-I-247.

Specifications for foundry castings (J. I. Case Co.). Eng. News, 1898-II-220.

Specifications for Pig Iron and Iron Castings for Philadelphia & Reading Ry. Co., by Robert Job. Eng. News, 1904-I-253.

Specifications for cast iron and finished castings. Eng. News, 1904-I-584.

Specifications for pig iron and castings, sampling clause. Eng. News, 1904-I-559.

Specifications for foundry supplies (J. I. Case Co.). Eng. News, 1902-II-184.

Standard specifications for gray iron castings. Proceedings Am. Soc. Test. Mat., Vol. 5, 1905, p. 71.

Specifications for aluminum castings. Proc. Am. Soc. Test. Mat., Year Book, 1910.

Proposed standard specifications for gray iron castings. (Adopted in amended form by letter ballot of the Amer. Soc. for Testing Materials, Sept. 1905.) References: Digest—"Civil Engineers Pocket Book," by Frye, p. 498. Proc. Am. Soc. for Testing Materials, Vol. 5, pp. 71-74; also 1913 Year Book, pp. 191-194.

Gray Iron Castings, by Henry Souther, Chm. Standards Comm. for Soc. of Automobile Engineers, 1910. Reference: Trans. of the Soc. of Automobile Engineers, Vol. 5, pp. 168-175. Note: For notes and instructions referring to above, see same Vol., pp. 176-202.

Castings—Continued.

Gray iron castings; molding or test pieces and standard specifications for. Abstract of report presented to American Foundry Men's Ass'n in June, 1901, by committee of same. Eng. News, Vol. 46, Aug. 1, 1901, p. 76.

See also "Aluminum;" "Iron and Steel," etc.

Catchbasin—see "Sewer."**Cattle Guards—**

Requirements of Canadian government commission. Eng. News, 1902-II-389.

Cement—

Philadelphia work. Comparison of American and foreign cements. Eng. News, 1896-I-306, 338.

South Australian government cement spec. Eng. News, 1896-II-404.

Standard specifications United States government engineer corps, 1896. 1897. Eng. News, 1898-I-230, 231, 274.

Canadian Society Civil Engineers' specifications for cement. Eng. News, 1903-I-129.

Report by board of engineers United States army on properties and testing. Eng. News, 1901-II-183.

Report on specifications for natural and Portland, by A. R. E. & M. W. Ass'n. Eng. News, 1903-1-285.

Natural and Portland. Am. Soc. Testing Mat. Eng. News, 1904-I-619.

Standard specifications for. (Adopted by Am. Soc. for Test. Mat., Aug. 16, 1909.) Approved by A. S. C. E. and A. R. E. & M. W. Ass'n and Ass'n Cement Mfgs. Reference: Amer. Civil Eng. Pocket Book, 1st edition, p. 482. "Reinforced Concrete Construction," by Hool. Vol. 2, p. 648. "Handbook for Architects and Builders." Pub. auspices Chicago Architects' Business Ass'n, Vol. 16, 1913, p. 199. Proc. Am. Soc. for Test. Mat., Vol. 9, 1909 pp. 116-130; also Year Book. "Standard Specifications," by Ostrup, pp. 65-69.

Standard specifications for cement. Adopted by the A. R. E. & M. W. Ass'n, 1905. (Joint committee. A. S. C. E.; Am. Soc. for Test. Mat. Latest revision, 1911, Year Book; A. I. of Arch.; U. S. Army; Ass'n Port. Cement Users, and Am. Ry. Eng. Ass'n.) Reference: Proc. of A. R. E. & M. W. Ass'n, Vol. 11, pp. 705-719. Note: Committee reports certain amendments during 1910, and recommends revision. Proc. of Ass'n, Vol. 11, Part 2, pp. 956-958. Trans. A. S. C. E., Vol. 66 (1910), p. 454; Vol. 77 (1914), p. 427. Proc. A. R. E. & M. W. Ass'n, 1903, Vol. 4, p. 380; 1905, Vol. 6, p. 704; and 1909, Vol. 10, p. 1338.

Sand-Cement as used by the U. S. Reclamation Service. Abstract of paper by Charles H. Paul in Proc. Am. Soc. C. E. — Feb. 1913. Eng. News, Vol. 69, p. 562.

British standard specifications for Portland. (Issued by the Engineering standards committee and supported by the various institu-

Cement—*Continued.*

- tions of Engineers. References: Practical Cement Testing, by Taylor, p. 308.
- United States Army standard specifications for. (Rec. about 1902 by Board of Engineers Officers on Testing Hydraulic Cements, for use in the Engineer Dept. U. S. Army.) References: Professional Papers No. 28, Corps of Engineers U. S. Army; Practical Cement Testing, by Taylor, p. 303.
- Standard method of testing and specifications for Portland. (Recommended by Comm. Canadian Soc. C. E.) Reference: Trans. Canadian Soc. C. E., Vol. 23, pp. 56-71.
- Cement, lime and clay products. Standard specifications adopted by the American Society for Testing Materials. Three Specifications, 1913 Year Book, pp. 254-286. Note: Above book contains all standard specifications of the society, sixty-three or sixty-four in number.
- Testing of hydraulic cements. Adopted by a Board of U. S. Engineer Officers in 1901, and used by the Engineer Dept. of the U. S. Army. Johnson, p. 515.
- Standard cement as used by the U. S. Reclamation Service. Eng. News, 1913-I-562.
- Recommended changes in Portland cement specifications. By Bureau of Science of the Philippine Islands. Eng. News, 1913-I-298.
- Portland specifications for Lackawanna railroad. Eng. News, 1913-I-298.
- Portland cement. Specifications for leading articles of same. Prepared by H. Von Schon for both quick-setting and slow-setting cement. Eng. Rec., Vol. 39, Mar. 11, 1899, p. 332.
- Portland cement. British standard specifications for. (Adopted by Engineering Standards Committee of Great Britain on Nov. 23, 1904.) Eng. News, Vol. 53, Mar. 2, 1905, pp. 227-228.
- Model specifications and tests for. (Adopted by the Bureau of Engineering of the city of Pittsburg. Better for general concrete work than for wearing surface and cement sidewalks. Municipal Engineering, Vol. 19, July, 1900, pp. 18-20.
- Hydraulic cements. Testing of same. Report Corps of Engineers, U. S. A. Specifications classified under purchase tests and acceptance tests, rather complete. Eng. Rec., Vol. 44, Sept. 21, 1901, pp. 274-277.
- Portland cement. Some comparisons of standard specifications for testing, by Duryee, Chemist California Portland Cement Co. Considers Russian specifications excellent for requirements of chemical composition and compares same with specifications of other countries. Eng. News, Vol. 47, Jan. 9, 1902, pp. 23, 24.
- National Board Fire Underwriters. Eng. News, 1906-I-588.
- United States government standard. Eng. News, 1911-II-301.
- Delaware, Lackawanna & Western R. R. Eng. News, 1913-I-185.
- Bonus system for purchase of cement. Eng. News, 1913-II-281.

Cement—Continued.

British and American standards compared. R. W. Lesley, *Eng. News*, 1905-II-523.

New German Standard Specifications for Cement, by H. Burchartz. *Eng. Rec.*, 1910-I-819.

Chains—

Wrought iron chains. Pennsylvania railroad company. Johnson, p. 234.

Chemicals—

Miscellaneous, Soaps and Chemicals, by R. Hose. Abstract of Pennsylvania R. R. specifications for materials. (In practical use for several years. Reprint *Rec. by Soc. of Automobile Engineers' Standard Committee*, 1911.) Reference: *Trans. of the Soc. of Automobile Engineers*. Vol. 6, pp. 400-445.

Coal and Coke—

Specifications and Proposal for Shipping Coal, by J. E. Woodwell. *Proc. Am. Soc. Test. Mat.*, Vol. 7, 1907, p. 554.

The Purchase of Coal, by D. T. Randall. Sampling selection and notes on specifications. *Trans. A. S. M. E.*, 1911, p. 313.

Specifications for city of Chicago. *Eng. News*, 1910-II-563.

Purchases by Third Avenue R. R. *Eng. Rec.* 1909-II-33.

Uniform coal specifications, Chicago Board of Pub. Wks. *Eng. Rec.*, 1910-II-475.

Coke, specifications and testing. *Eng. News*, 1912-I-657.

Concrete—

Report of joint committee on concrete and reinforced concrete. (Editorial.) *Eng. News*. Vol. 69, p. 273.

Specifications for concrete work. St. Louis. *Eng. News*, Vol. 67, p. 228.

Railroad concrete work. Illinois Central railway company. Johnson, p. 328.

Concrete Specifications for Bridge Structures. by United States Office of Public Roads. *Eng. Rec.*, Vol. 68, p. 305.

Proposed standard specifications for architectural concrete stone. (Submitted by Comm. of Nat. Ass'n Cement Users in 1911.) References: *Engineering Work in Town and Cities*, by McCullough, 2d edition, p. 239.

Concrete dam. Extracts from specifications for construction of Elephant-Butte Dam, Rio Grande Project of U. S. R. S. *Eng. News*, Vol. 69, 1913, pp. 120-122.

General Specifications for Concrete Bridges, by W. J. Watson, Consulting Engineer. 82 pages, 50c. Address M. A. Vinson, Caxton Bldg., Cleveland, O.

General Specifications for Concrete and Reinforced Concrete, Including Finishing and Waterproofing (1913), by Jerome Cochran. Pub. by D. Van Nostrand Co.

Concrete—*Continued.*

Standard specifications for cement hollow blocks. (Adopted Jan., 1908, by the Nat'l Ass'n of Cement Users, Philadelphia, Pa.) References: Engineering Work in Towns and Cities, by McCullough, 2d edition, p. 247. Proc. of the Nat'l Ass'n of Cement Users, Vol. 4, pp. 185-193.

Standard Specifications for Reinforced Concrete, by Ostrup (McGraw-Hill Book Company), pp. 75-93.

Standard specifications for plain and reinforced concrete, and steel reinforcement. (Adoption recommended by Comm. on Masonry of A. R. E. & M. W. Ass'n, 1910.) References: Walls, Bins & Grain Elevators, by Ketchum, 2d edition, pp. 520-525; Proc. A. R. E. & M. V. Ass'n, Vol. 11, part 2, pp. 962-967; 1911 Year Book, pp. 188-194; Manual of recommended practice of the same Ass'n; Recommended Practice for Designing Reinforced Concrete Structures (adoption recommended by committee of A. R. E. & M. W. Ass'n, 1910); Proc. of Ass'n, Vol. 11, part 2, pp. 968-969. See also Manual of Recommended Practice of the above association,

Specifications and Design Standards for Reinforced Concrete Structures, by Ernest McCullough. Eng. News, 1913-I-282.

Specifications for concrete and reinforced concrete. Joint committee A. S. C. E., Am. Soc. Test. Mat., A. R. E. & M. W. Ass'n, and A. A. Portland Cement Mfgs. Eng. News, 1913-I-258.

Reinforced concrete regulations for New York city and for Cleveland, Ohio. Eng. News, 1912-I-98 et seq.

Specifications for floors. Eng. News, 1895-I-189.

German specifications for design, constructing and testing of concrete structures. L. L. Moisseiff. Eng. News, 1905-II-478.

Blocks, specifications for. Nat'l Ass'n Cement Users. Eng. News, 1908-I-70. Nat'l Ass'n Mchy. Mfgs. Eng. News, 1906-I-153.

Manufacture of, for hollow walls, F. W. Haglock. Eng. News, 1905-I-440.

Concrete slabs, specifications for. Eng. News, 1910-I-443.

Concrete for new ship lock at Sault Ste. Marie. Eng. News, 1911-II-276.

Specifications and methods of test. Eng. News, 1912-I-557.

Concrete specifications for bridge substructure. U. S. Office of Public Roads. Eng. Rec., 1913-II-305.

Atlantic Avenue subway, Brooklyn. Eng. News, 1902-I-420.

Aurora, Elgin & Chicago Railway Measurement of Cement and Consistency of concrete. Eng. News 1902-II-285.

Hudson River tunnel work. Eng. News, 1913-II-337.

Illinois Central Railroad bridges and culverts. Eng. News, 1901-II-44.

Report A. R. E. & M. W. Association. Eng. News, 1902-I-246; 1903-I-274, 284.

Reservoir lining, Aurora, Ill. Eng. News, 1902-I-423.

Proportioning concrete. U. S. Navy Dept. Eng. News, 1912-II-201.

Concrete—Continued.

- Specifications and design standards for reinforced concrete structure. Ernest McCullough. Eng. News, 1913-I-282.
- Field Testing and Inspection on Reinforced Concrete Building Contracts, by G. H. Bayles. Paper before Nat'l Ass'n Cement Users. Specifications and methods of testing. Eng. Rec., 1912-I-528.
- Consistency of concrete. Specifications of The Concrete Institute. Eng. Rec., 1912-I-185.
- Proposed standards for measuring concrete construction. Nat'l Ass'n of Cem. Users. Eng. Rec., 1912-I-387.
- Depositing concrete under water. Results of study by Committee of Am. Ry. Eng. Ass'n. Eng. Rec., 1912-I-328.
- Specifications and methods of tests for concrete materials. Nat'l Ass'n of Cement Users progress report. Eng. Rec., 1912-I-349.
- Reinforced concrete in New York City. Regulations adopted in 1911. Eng. Rec., 1912-I-26.
- Specifications for scrubbed concrete surface. Report presented to Nat'l Ass'n Cement Users. Eng. Cont., Jan. 4, 1911, p. 5.
- Standard plans and specifications for retaining walls, Seattle, Wash. Eng. Cont., July 19, 1911, p. 58.
- Reinforced concrete pipe culverts for railways. Sample specifications from various railways. Eng. Cont., Oct. 23, 1912, p. 473.
- Methods of testing for concrete materials. Report of Committee Nat'l Ass'n of Cement Users. Eng. News, 1913-I-42.
- Specifications and methods of test for concrete materials. Eng. Rec., 1911-I-349.
- Specifications and Design Standards for Reinforced Concrete Structures. Abstract of paper before Ill. Soc. Engrs. & Surv. Jan., 1913, by Ernest McCullough. Eng. News, Vol. 69, p. 282.
- Reinforced Concrete Regulations. Uniform regulations adopted by building superintendents in five boroughs of New York City. Eng. News, Vol. 67, p. 98.
- See also "Measurement."

Copper—

- Standard specifications for copper wire, bars, cakes, slabs, billets, ingots and ingot bars. Adopted, 1911. Proc. Am. Soc. Test. Mat., Vol. 11, 1911, p. 143.
- Standard specifications for electrolytic copper wire, bars, cakes, slabs, billets, ingots and ingot bars. Am. Soc. Test. Mat., Vol. 13, 1913, p. 218.
- Standard specifications for lake copper, wire, bars, cakes, slabs, billets, ingots and ingot bars. Am. Soc. Test. Mat., Vol. 13, 1913, p. 214.

Culverts—

- Specifications for corrugated metal culverts in Minnesota. From bulletin by highway commission. Geo. W. Cooley, State Engr. Eng. Cont., July 1, 1914, p. 17.
- See also "Concrete."

Curb—See "Sidewalk, Curb and Gutter."

Dams—

Wachusett dam, details of. A. D. Flinn. Eng. News, 1900-II-177.
The New Kensico Dam (masonry dam), by A. D. Flinn. Eng. Rec., 1912-I-772.

Elephant Butte dam. Extracts from specifications, U. S. Reclamation Service. Eng. Rec., 1913-I-120.

New regulations governing the design and construction of dams. New York State Conservation Comm. Eng. Rec., 1912-I-74.

Abstract of Specifications for Earthen Dam for McAlester, Okla., by J. W. Holman. Eng. Cont., Nov. 13, 1912, p. 547.

Specifications for timber dam at Hymelia Crevasse, La. Eng. Cont., Sept. 18, 1912, p. 328.

Earthen dam for storage reservoir for irrigation purposes. Johnson, p. 130.

Masonry. Kanasha River. Wm. P. Craighill, Maj. of Engineers. Haupt, p. 71.

Contract. No. 5 Soughborough, of the Boston Waterworks. Johnson, p. 358.

Specifications for the Arrow Rock dam U. S. Reclamation Service. Eng. News, 1913-I-118.

See also "Concrete."

Drainage—see "Excavation."

Drain Tile—see "Pipe."

Earthwork—see "Excavation."

Electrical—General—

Engineering Specifications, by Frank F. Fowle before Armour Inst. of Tech., Branch of A. I. E. E. Discusses the relation of specifications to contracts and matters related, giving three examples of specifications. Proc. A. I. E. E., Sept., 1911, Vol. 30, No. 9, pp. 2029-2047.

Standardization rules of the A. I. E. E. (As approved June 27, 1911.)

References: Trans. of the A. I. E. E., Vol. 30, Part 3, p. 2539.

Note: Preliminary draft of revised rules printed in Nov., 1913. Address, 33 W. 39th St., N. Y.

Rules of the National Electric Light Ass'n. (Adopted 1891 and amended Feb., 1892.) References: Electric Lighting Specifications, by Merrill. 1st ed., p. 118.

Rules of the National Board of Fire Underwriters. (Edition of Jan. 1, 1895.) Reference: Electric Lighting Specifications, by Merrill. 2d ed., p. 154.

Electrical Inspection. Section of review of City of Chicago, Governing Electrical Inspections. (Adopted March 13, 1911.) Reference: Handbook for Architects and Builders, Vol. 16, 1913, p. 165.

Electrical inspection. Regulations governing Commonwealth Edison Company's system. Reference: Handbook for Architects and Builders, Vol. 16, 1913, p. 173.

Electrical—General—Continued.

Protection of electric service employees, rules for. Being an order of the New York Public Service Commission. First District. Eng. News, 1913-I-1131.

See also "Transmission Lines."

Electric Generators and Motors—

Specifications for Performance and Ratings of Generators and Motors, by W. L. Waters. Notes and points on operating requirements. N. E. L. A. Thirty-second convention, Vol. 11, 1909, p. 443.

Electric generators. St. Charles St. Railroad Co., New Orleans, La. Johnson, p. 414.

A. C. Generator. Typical Specification for an Alternating Current Generator, "Electrical Machine Design," by Gray, pp. 312-314.

D. C. Generator. Typical Specification for a Direct Current Generator, "Electrical Machine Design," by Gray, pp. 153-155.

Induction Motors. Typical Specifications for a Large Induction Motor, "Electrical Machine Design," by Gray, pp. 422-424.

Standardization rules A. I. E. E. Performance specifications and tests. A. I. E. E., Vol. 24, 1907, Part II, p. 1799.

Parallel operation of alternating current generators. Engine requirements. Specifications of Westinghouse El. & Mfg. Co. E. M. Tingley and H. E. Longwell. Eng. News, 1902-I-498.

Electric Insulators—

Testing of and proposed standard specifications. C. E. Skinner. Eng. News, 1908-II-44.

Specifications covering inspection and tests of high tension line insulators of porcelain for over 25,000 volts. Committee report. Proc. A. I. E. E., Oct. 1914.

Specification and Analytical Procedure for 30 per cent. Hevea Rubber Insulating Compound. Report of Joint Rubber Insulation Committee, 1913. Reprinted by Simplex Wire and Cable Co., Boston, Mass.

Electric Lighting—

Requisites of modern lighting generator sets, H. G. Reist. Eng. News, 1900-II-423.

Electric Lighting. Rules and requirements of the New England Insurance Exchange for electric lighting. (Adopted Sept. 27, 1890. Revised in conjunction with Comm. from New England Electric Exchange.) References: Electric Lighting Specifications, by Merrill, 1st ed., p. 154.

Electric street lighting plant. Specifications for arc system drawn up for City of Toronto, Ont., by the city engineer. Large Plant. Few specifications for work of this kind published. Eng. News, Vol. 32, Aug. 23, 1894, pp. 148, 149.

Street lights standard specifications for. Editorial. Eng. Rec., 1913-II-595.

Street Lighting by arc lamps, specifications for. Used for street arc lights in Oswego, N. Y. Of some practical interest. Eng. News, Vol. 33, April 11, 1895, p. 234.

Electric Lighting—Continued.

Electric lamps. Abstract of Pennsylvania R. R. specifications for materials. (In practical use for several years. Reprinted record, by Soc. of Automobile Engineers Standard Committee, 1911.) Reference: Trans. of the Soc. of Automobile Eng., Vol. 6, pp. 400-445. Installation of an electric lighting station in a small city. Johnson, p. 254.

Electric Railway and Miscellaneous—

Machinery and track construction of an electric railway. St. Charles St. Railroad Co. Johnson, p. 404.

Track and overhead construction for an electric railway in a country town. American Society of Civil Engineers. Johnson, p. 429.

Transformers. Standard Specification for Oil Immersed, Self-Cooled Transformers, "Electrical Machine Design," by Gray, pp. 494-496.

Railway Signal Association standard specification for switch boards. Proc. Ry. Signal Ass'n, 1911, Vol. 8, p. 319.

Electrical signal service. Various comm. reports and discussions on same. Recommended specifications, requisites and rules of the Railway Signal Ass'n. "Journal of the Railway Signal Ass'n," Vol. 9, 1912.

See also "Transmission Lines."

Engines—see "Steam Engine."**Excavation—**

General specification for construction of open drainage ditches. Office Exp. Station, U. S. Dep't Agric. Eng. Cont., July 5, 1911, p. 21.

Preparation and Enforcement of Drainage Specifications, by J. L. Parsons. Eng. Cont., Dec. 27, 1911, p. 692.

Specifications for tunnel excavation. A. R. E. & M. W. Ass'n, 1905. Vol. 6, p. 125.

Notes on Specifications for Earthwork in Railway Construction. Paper before Am. Soc. Eng. Cont., by J. H. Bacon. Eng. Cont., Feb. 23, 1910, p. 175.

Grading. Railroad grading used by the Pennsylvania Railroad. Johnson, p. 123.

Grading. Falls Drive, Philadelphia. Haupt, p. 147.

Excavations under water. Used by Col. O. M. Poe, U. S. Army. Johnson, p. 126.

Specifications for excavations. In use by U. S. Reclamation Service. "Principles of Irrigation Engineering," by Newell and Murphy, pp. 50-52.

Standard Plans and Specifications for Grading in Seattle, Wash., by R. H. Thomson. Eng. Cont., July 5, 1911, p. 7.

Plowing as a test of classification. Eng. Rec., 1909-I-366, 488.

Plow test for classification. J. A. Fulton. Eng. News, 1904-I-179.

Classification of excavation and embankment. Eng. Rec., 1907-I-316, 323.

Classification of excavated material. Eng. Rec., 1903-I-274, 347.

Excavation—Continued.

Dispute over grading classification. Legal decision Minnesota supreme court. Eng. Rec., 1911-II-760.

Grading, masonry, bridges and rails as used on Cincinnati Southern Ry. Haupt, p. 164.

See also "Measurement;" "Railways;" "Tunnel."

Excavation, Dredging—

Measurement, comparison of place and scow. Eng. News, 1904-II-197.

Typical specifications for dredge work in alluvial land drainage of Mississippi valley, by Morgan Eng. Co. Eng. Cont., Oct. 4, 1911, p. 357.

See also "Measurement."

Embankments and Retentions—

Brush mattress work. E. F. Linderman. Eng. News, 1912-I-672.

Soil binders for protecting embankment from erosion. Eng. News, 1912-II-74.

Rubble lake embankment, Rutland Canadian R'y. J. W. Burke. Eng. News, 1903-I-48.

Building levees to confine flood waters. State of Louisiana for building levees on the banks of the Mississippi river. Johnson, p. 356.

Fences—

Specifications or standard right-of-way fences. Committee report covering material and workmanship. A. R. E. & M. W. Ass'n, 1906-Vol. 7, p. 451; 1911, Vol. 12, p. 123.

Floors—

Specifications for composite floor with tar concrete base. Practice of Lockwood, Green & Co., Architects. Eng. Cont., June 1, 1910, p. 493.

Specifications for waterproofing solid steel floor railroad bridges. S. T. Wagner. Proc. A. S. C. E., Vol. XL, p. 2943; Eng. Cont., Jan. 27, 1915, p. 79.

See also "Bridge;" "Water Proofing;" "Concrete."

Flying Machine—

Signal Corps specifications for a heavier than air flying machine. Trans. A. S. M. E., Vol. 30, 1908, p. 686.

Frogs and Switches—

Specifications for frogs and switches. Progress committee report. A. R. E. & M. W. Ass'n, 1909, Vol. 10, p. 409.

Specifications for spring and rigid frogs. Committee report. Material and workmanship. A. R. E. & M. W. Ass'n, 1910, Vol. 11, p. 936.

Galvanizing—

Galvanizing. Specifications for galvanizing for iron or steel. Appendix C. to specifications for overhead crossings for electric light

Galvanizing—Continued.

and power lines, proceedings of technical societies Chicago, June, 1913 (36th annual convention). Reference: Nat. Elec. Light Ass'n, pp. 581-583.

Garbage Reduction—

Specification for furnace at navy yard, League Island, Pa. Eng. News, 1902-I-5.

Specification for garbage disposal, New York city. Eng. News, 1913-II-267.

Gasoline—

Specification for gasoline for internal combustion motors. Paper before Am. Soc. Test. Mat., by Dr. A. Sommer. Eng. Rec., 1910-II-166, and Proc. Am. Soc. Test. Mat., Vol. 10, 1910, p. 460.

Grade Crossings—

Buffalo, New York, specifications for crossings. Eng. News, 1895-I-195.

Grade crossings in paved streets. Report Am. Ry. E. & M. W. Ass'n. Eng. News, 1909-I-308.

Gravel—

Specifications for ballast. Report Am. Ry. & M. W. Ass'n. Eng. News, 1903-I-285.

Standards in United States, Canada and Mexico. Eng. News, 1900-II-142.

Filter gravel and sand. Albany Water Filtration Plant. Johnson, p. 294.

See also "Ballast."

Gutter—

See "Sidewalk, Curb and Gutter."

Harbor and River Improvement—

Harbor and river improvements. Cedar Keys, Fla. A. N. Damrell, Capt. U. S. Engrs. Haupt, p. 55.

Stone breakwater. Block Island, Rhode Island. G. K. Warren, U. S. Engr. Haupt, p. 57.

Breakwater of crib-work. Cleveland breakwater. C. E. Blunt, Lieut. Col. of Engineers. Haupt, p. 59.

Iron landing pier. Lewes, Delaware. Haupt, p. 61.

Removing snags, etc. Minnesota river. F. U. Farquhar, Maj. of Engineers. Haupt, p. 63.

Removing rock. East river and Hell Gate, N. Y. John Newton, Lieut. Col. Engineers. Haupt, p. 58.

Canal locks. Tennessee river. W. R. King, Capt. of Engineers. Haupt, p. 64.

Light house. New Haven, Conn. Haupt, p. 77.

Also see "Embankments and Revetments."

Highway—

See "Pavement and Road Construction."

Hydrants—

- Mill hydrant specification. Nat'l Fire Prot. Ass'n. Eng. News, 1901-I-455.
- Proposed standard specifications for post hydrants. Committee report to N. E. W. W. Ass'n. Eng. Cont. May 8, 1912, p. 530.
- Standard specifications for water works hydrants and valves. Adopted by Am. W. W. Ass'n. Eng. News, Aug. 7, 1913, p. 265.
- Proposed standard specifications for post hydrants. (Final Report of Comm. Presented at Jan., 1912, meeting of association.) Reference: Journal New England W. W. Ass'n, Vol. 26, No. 1, 1912, p. 77.
- Water works hydrant and valves; standard specifications for, edited by American Water Works Association, June, 1913. Eng. News, Vol. 70, p. 265.

Illumination—

- Desirability of standard specifications for street lighting. Eng. Rec., 1913-I-595.
- See also "Electric Lighting."

Iron and Steel—

- Iron and steel, classification of. Classification and definitions of above materials as given by Wm. Kent in 1883 in expert testimony. Good classification and clear definition of technical meaning of commercial forms. Railroad and Engineering Journal, Vol. 61, April, 1887, pp. 155-158.
- Abstract of Pennsylvania R. R. specifications for materials. (In practical use for several years. Reprint rec. by Soc. of Automobile Standards Committee, 1911.) Reference: Trans. of the Soc. of Automobile Engineers, Vol. 6, pp. 400-445.

Axles

- Locomotive axles and forgings. Eng. News, 1903-II-20.
- Steel Axles—Manufacture and Specifications, by J. L. Replogle. Eng. News, 1904-I-471.
- Standard specifications for steel axles. Proc. Am. Soc. Test. Mat., Vol. 5, 1905, p. 56.
- Standard specifications for heat-treated carbon steel axles, shafts and similar parts. (Adopted 1911.) Proc. Am. Soc. Test. Mat., Vol. 11, 1911, p. 63.
- Standard specifications for cold-rolled steel axles. Am. Soc. Test. Mat., Vol. 13, 1913, p. 156.

Bearing Balls and Rollers

- Specifications for ball bearings for large sluice gates and gate valves. Coffin Valve Co. Eng. News, 1902-I-390.
- Roller steel for railway bridges. Report of A. R. E. & M. W. Ass'n. Eng. News, 1902-I-282.

Boiler Plate and Rivet Steel

- Comparison of various railway standards. Eng. News, 1897-I-44.
- Specifications for boiler plate, rivet steel, steel castings and steel forgings. Report of committee, with discussion. Trans. A. S. M. E., Vol. 23, 1902, p. 632; revise in Vol. 24, 1903, p. 921, and Vol. 25, 1904, p. 321.
- Standard specifications for open hearth, boiler plate and rivet steel. Proc. Am. Soc. Test. Mat., Vol. 9, 1909, p. 62.
- Standard specifications rivet steel for ships. Am. Soc. Test. Mat., Vol. 13, 1913, p. 148.
- Specifications for boiler plate steel (similar to Am. Soc. Test. Mat.). Am. Soc. M. E., Vol. 36, 1914, p. 985.
- Standard specifications for boiler plate, rivet steel, steel castings and steel forgings. (Submitted by the committee at Amer. Soc. of Mechanical Engineers, 1903 or 1904.) See Trans. A. S. M. E., Vol. 25, p. 322.
- Structural and boiler steel specifications of American steel manufacturers. Recent revision of standards used. Iron Age, Aug. 22, 1912, Vol. 90, pp. 409-411.
- Fire Box Steel—Failures and Specifications. Abstract of paper before Am. Soc. Test. Mat., by M. H. Wickhorst. Eng. News, Vol. 56, p. 76.

Castings and Forgings

- Specifications for boiler plate rivet steel, steel castings and forgings. Report of committee. Trans. A. S. M. E., Vol. 23, 1902, p. 632; Vol. 24, 1903, p. 921; Vol. 25, 1904, p. 321.
- Standard specifications for steel castings and forgings. Proc. Am. Soc. Test. Mat., Vol. 5, 1905, pp. 53, 59.
- Standard specifications for malleable castings. Proc. Am. Soc. Test. Mat., Vol. 4, 1904, p. 95.
- Standard specifications for blooms, billets and slabs for carbon steel forgings. Proc. Am. Soc. Test. Mat., Vol. 13, 1913, p. 166.
- Review of various specifications for C. I. and steel casting. Committee report tabulated summary. A. R. E. & M. W. Ass'n, 1905-6-32.
- Specifications for Steel Castings, by Henry Souther, Chm. Standards Comm. for Soc. of Automobile Engineers, 1910. Reference: Trans. of Soc. Automobile Engineers, Vol. 5, pp. 168-175. Note: For notes and instructions referring to above, see same Vol., pp. 176-202.

See also "Castings."

Cold Drawn Steel

- Tentative specifications for cold-drawn steel; Bessemer and open hearth automatic screw stock. Proc. Am. Soc. Test. Mat., Vol. 13, 1913, p. 191; also Vol. 14, 1914, p. 174.

Malleable Iron

- Specifications for Malleable Iron, by Henry Souther, Chm. Standards Comm. for Society of Automobile Engineers, 1910. Ref-

Iron and Steel—Continued.

erence: Trans. of the Society of Automobile Engineers, Vol. 5, pp. 168-175. Note: For notes and instructions referring to above, see same Vol., pp. 176-202.

See also "Wrought Iron."

Pig Iron

Specifications or code for ordering and sampling pig iron. Report Am. Soc. Test. Mat., Eng. News, 1909-II-56; Proc. Am. Soc. Test. Mat., Vol. 9, 1909, p. 111.

Proposals for international export specifications for pig iron. Proc. Am. Soc. Test. Mat., Vol. 14, 1914, p. 154.

Railroad Rails

Manufacturers' standard specifications for steel rails. (Adopted Jan. 1, 1899.) Reference: Carnegie Steel Co.'s Handbook, 1903, p. 229. Ass'n Am. Steel Mfgs. issued standard specifications in Jan., 1909. See Leaflets, Carnegie Steel Co.

Standard Rail Specifications. Comparison of American Specifications—Steel Rails, by Sellev, Prin. Asst. Engineer Michigan Central R. R., pp. 463-500 (D. Van Norstrand Co.). Also contains full bibliography of rail specifications.

Comparative rail specifications. (Specifications of five different societies or associations compared.) Railroad Age Gazette, 1909, Vol. 46, pp. 1066-1071.

Specifications for carbon steel rails. Proc. Am. Ry. Engineering Ass'n, 1912, Vol. 13, p. 565.

New specifications for steel rails adopted by the A. R. E. & M. W. Ass'n, Iron Age, Vol. 89, p. 816.

Specifications for Steel Rails, by Robert Job, Chemist of Philadelphia and Reading Ry. Co. Gives discussion of composition as well as manufacture of material. Also copy of specifications of above railway company. American Engineer and Railroad Journal, Oct. 1902, pp. 310-311.

Sixty-pound iron rails. Cincinnati Southern Railroad Company, Haupt, p. 177.

Specifications Heavy Rails Made West of Alleghenies, by R. W. Hunt. Eng. News, 1895-II-252.

New York Central standard. Eng. News, 1893-II-300.

Am. Soc. Testing Materials, discussion of changes in specifications. Eng. News, 1902-I-511.

Specifications for Bessemer steel rails of the A. R. E. & M. W. Ass'n. Eng. News, 1904-I-275.

Chemical Specification. R. W. Hunt. Eng. News, 1900-II-68.

Specifications International Ass'n for Testing Materials. Eng. News, 1901-II-11.

Report A. R. E. & M. W. Ass'n. Process and chemical properties for rails. Eng. News, 1902-I-244.

Iron and Steel—Continued.

- American Inst. Mining Engrs. proposed standard specifications. W. R. Webster. Eng. News, 1901-I-352.
- Rail sections—British standard and a comparison of American and British sections. Eng. News, 1905-II-84.
- Canadian Pacific Ry. specifications for 85-pound rail. F. P. Gutelius. Eng. News, 1909-I-272.
- Specifications reported by A. R. E. & M. W. Ass'n. Eng. News, 1910-I-375, 384.
- American Railway Ass'n specifications for Bessemer and open-hearth steel rails. Eng. News, 1908-I-531.
- American Railway E. & M. W. Ass'n. Wearing quality and freedom from breakage. Eng. News, 1905-I-337.
- American Society C. E. recommendations for Bessemer steel rails. Eng. News, 1908-I-105.
- American Society for Test. Mat. proposed standard specifications. Eng. News, 1906-I-726; 1907-II-8; 1907-II-18; 1908-II-22.
- Pennsylvania Railroad specifications. Eng. News, 1908-I-426; 1909-I-50.
- Specifications and rail breakage. H. M. Howe. Eng. News, 1912-I-660.
- Standard specifications for steel rails. Am. Soc. Test. Mat. Eng. Rec., 1907-I-774.
- Standard specifications for steel rails. Proc. Am. Soc. Test. Mat., Vol. 7, 1907, p. 44; Vol. 8, 1908, p. 44.
- Standard specifications for Bessemer steel rails. Proc. Am. Soc. Test. Mat. Vol. 9, 1909, p. 62.
- Standard specifications for open-hearth steel rails. Proc. Am. Soc. Test. Mat., Vol. 9, p. 66, and Year Book 1915.
- See also "Rails."

Railway Rolling Stock

- Standard Specifications for locomotive cylinders. Proc. Am. Soc. Test. Mat., Vol. 4, 1904, p. 69.
- Standard specifications for steel tires. Proc. Am. Soc. Test. Mat., Vol. 9, 1909, p. 58.
- Standard specifications wrought and solid carbon steel wheels for electric railway service. Proc. Am. Soc. Test. Mat., p. 160, Vol. 13, 1913.
- See also "Cars;" "Locomotive," etc.

Reinforcing Bars

- Standard specifications for steel bars. Eng. News, 1910-I-704.
- Reinforcing bars, proposed standard. T. L. Condron. Eng. News, 1911-II-73, 87, 150.
- Standard specifications for reinforcing bars of Ass'n of American Steel Mfrs. Eng. Cont., June 1, 1910, p. 492.
- Abstract embodying portions applicable to concrete reinforcement from the standard specifications for structural steel. Adopted by A. R. E. & M. W. Ass'n. Trans. A. S. C. E., Vol. 66, 1910, p. 459.

Iron and Steel—Continued.

Specifications for metal reinforcement. Progress report special committee on concrete. Trans. A. S. C. E., Vol. 77, 1914, p. 430.

Definitions—Express Executory Contract—Requirements of a Valid Contract. Standard specifications for metal reinforcement. (Adopted Mar. 16, 1910, by American R. E. Ass'n.) References: Reinforced Concrete Construction, by Hool, Vol. 2, p. 652, 1911. Year Book of A. R. E. Ass'n, pp. 188–190.

Standard specifications for steel reinforcing bars. (Adopted by American Soc. for Test. Mat., June 1, 1912.) References: Handbook for Architects and Builders, published under auspices Chicago Architects' Business Association, Vol. 16, 1913, p. 197. Proc. Am. Soc. for Test. Mat., Vol. 11, 1911, p. 66; Vol. 12, 1912, p. 161–169. Note: Revision Aug. 23, 1913; Proc. Vol. 13, 1913, p. 153; also 1913 Yearbook, pp. 80–83.

Splice Bars and Stay Bolts

Standard specifications for steel splice bars. Proc. Am. Soc. Test. Mat., Vol. 9, 1909, p. 56, and Vol. 13, 1913, p. 131.

Proposed standard specifications for staybolt iron. Proc. Am. Soc. Test. Mat., Vol. 7, 1907, p. 157, and Vol. 10, 1910, p. 93.

Manufacturers standard specifications for steel splice bars. (Adopted Jan. 1, 1899.) References: Carnegie Steel Co.'s Handbook, 1903, p. 231.)

Spring Steel

Specifications for spring steel. Proc. Am. Soc. Test. Mat., Vol. 7, 1907, p. 198.

Structural Steel

Standard American specifications. Eng. News, 1900–I–322.

Table of grades steel for bridges and buildings in some countries that have adopted standards. Eng. News, 1902–I–516.

Table of tensile strength and elongation of steel used on notable bridges. Eng. News, 1902–I–516.

Material workmanship for steel structures Am. R. E. & M. W. Ass'n. Eng. News, 1913–I–274, 283.

Desirability of standard specifications for bridge and ship steel. Eng. News. 1907–I–622.

Specifications for and tests of steel. Eng. News, 1912–I–658.

American Bridge Co. Radical innovations in steel work specifications. Eng. News, 1913–I–364.

Standard, for bridges, ships, forgings and rails of Am. Soc. Test. Mat. Eng. News, 1901–II–11, 12, 56; 1902–I–355.

Specifications for steel street bridging and station building, Pennsylvania R. R. Terminal, New York. Trans. A. S. C. E., Vol. 69, p. 214, 1910.

Standard specifications for structural steel for bridges. Proc. Am. Soc. Test. Mat., Vol. 9, 1909, p. 37.

Iron and Steel—Continued.

- Standard specifications for structural steel for buildings. Proc. Am. Soc. Test. Mat., Vol. 9, 1909, p. 47.
- Standard specifications for structural steel for ships. Proc. Am. Test. Mat., Vol. 9, 1909, p. 42, and Vol. 13, 1913, p. 143.
- Steel framework of buildings. Standard specifications. By Ostrup (McGraw-Hill Book Company), pp. 1-12.
- Specifications for material and workmanship for steel structures. (Adopted by American Railway & Maintenance of Way Ass'n.) Reference: "Walls, Bins and Grain Elevators," by Ketchum, p. 536.
- Specifications for steel structures, design, details of construction and workmanship. (Adopted by the American Bridge Company.) Reference: Pamphlet—Specifications and Tables for Steel Framed Structures, Am. Bridge Co. of New York, Chicago edition, 1913.
- New specifications for structural steel work. Issued by the American Bridge Company. Eng. Rec., Vol. 67, p. 264.
- New specifications for steel work of buildings. Editorial, Eng. Rec., Vol. 67, p. 254.
- Specifications for Steels, by Henry Souther, Chm. Standards Comm. for Soc. of Automobile Engineers, 1910. For notes and instructions referring to above, see Vol. 5, pp. 176-202.
- Abstract of Pennsylvania Railroad specifications for materials. (In practical use for several years. Reprint rec. by Soc. of Automobile Engineers' Standard Committee, 1911.) See S. A. E., Vol. 6, pp. 400-445.
- Three radical innovations in new steel specifications. Eng. News, Vol. 69, p. 364.
- Wrought iron—specifications and tests for. Eng. News, 1912-I-657.
- Standard specifications for wrought iron. Proc. Am. Soc. Test. Mat., 1901, Vol. 1, p. 231; Vol. 13, 1913, p. 185.

Kerosene—

- Necessary reforms in specifications for kerosene illuminating oil. Paper before Am. Soc. Test. Mat., by Dr. A. Sommer. Eng. Rec., 1910-II-166; Proc. Am. Soc. Test. Mat., Vol. 10, 1910, p. 463.

Lathing—

- New York Bureau of Buildings. Rules for lathing and plastering. Eng. News, 1912-II-268.
- See also "Buildings."

Lime—

- Proposed specifications for lime, both hydrated and quick lime. Am. Soc. Test. Mat., Vol. 13, 1913, p. 315; Vol. 14, 1914, p. 214.
- Hydrated lime, tests and specifications. R. K. Meade. Eng. News, 1911-I-557.
- Lime for water purification. W. F. Monfort. Eng. News, 1912-II-889.
- Recommended clauses for purchase of lime for water purification. Paper before Central States W. Wks. Ass'n, by W. F. Monfort. Eng. Cont., Nov. 13, 1912, p. 547.

Lime—Continued.

Proposed standard specifications for lime. *Proc. Am. Soc. Test. Mat.*, Vol. 13, 1913, p. 315.

Lightning Protection—

Specifications for protection of buildings. Report Nat'l Fire Protection Ass'n. *Eng. News*, 1906-I-577.

Locks, Canal—

See "Canal Locks;" "Concrete;" "Masonry."

Locomotive—

Locomotive: American Pattern, Haupt, p. 187.

Locomotive: Mogul Pattern, for Dom Pedro Segundo Railway of Brazil, Haupt, p. 186.

Locomotive: Lehigh Valley R. R. Consolidation Pattern, Haupt, p. 184.

Schenectady Locomotive Work's specifications for eight-wheel locomotive engine furnished Purdue University about the year 1891 or 1892. *Locomotive Performance*, by Gross, pp. 47-49.

See "Iron and Steel—Railway Rolling Stock;" "Axles;" "Tires."

Machine Tools—

Specifications of Penn. R. R. & Am. Br. Co. *Eng. News*, 1904-I-449, 455.

Requirements in up-to-date shops, lathes and screw machines. John Ashford. *Eng. News*, 1901-I-179.

Manholes—see "Sewer."**Maps—**

Specifications for railway maps. Cal. State R. R. Comm. (Ed.) *Eng. News*, 1912-I-1237.

Specifications for Railway Maps. Cal. State R. R. Comm., by R. A. Thompson. *Eng. News*, 1912-II-120.

Masonry—

Abstract of Report to Am. Ry. & M. W. Ass'n. *Eng. News*, 1902-I-245.

Masonry piers East River Bridge, N. Y. *Eng. News*, 1901-I-454.

Specifications for Work and Materials, by A. D. Flinn. *Eng. News*, 1912-I-776.

Recommended standard specifications for stone masonry. (Adopted by the Amer. Ry. Engineering Ass'n, 1908.) References: "Walls, Bins & Grain Elevators," by Ketchum, 2d edition, p. 531. "A Treatise in Masonry Construction," by Baker, pp. 729-732. *Proc. Amer. Ry. Eng. & M. W. Ass'n*, Vol. 9, pp. 650-655, 659. Late Revision 1911 Year Book, pp. 183-188.

Masonry of railroad bridge over street. Pennsylvania R. R., Pittsburgh, Pa. Joseph M. Wilson, *Engineer Bridges*. Haupt, p. 139.

Bridge: Girard Ave., Philadelphia. Joseph M. Wilson, *Engineer Bridges*. Haupt, p. 144.

First class bridge masonry. Johnson, p. 157.

Masonry—Continued.

Specifications used by the Pennsylvania Railroad Company. Johnson, p. 148.

Stone bridge masonry used by the Chicago, Milwaukee & St. Paul Railway. Johnson, p. 145.

General specifications for Kensico Dam of Board of Water Supply of New York City. Eng. News, Vol. 67, 1912, pp. 776-779.

Large stone dam. New Croton dam, New York City. Johnson, p. 151.

See also "Concrete;" "Canal Locks;" "Rock."

Measurements—

Proposed method for the measurement of concrete construction. Committee Report Nat'l Ass'n of Cement Users. Eng. News, Vol. 67, p. 577. Eng. Rec. Vol. 65, p. 387.

Measurement rules. Chicago rules for measuring excavation and concrete work. (Adopted 1910 by W. S. of E., Chicago Architects' Business Ass'n and Masons' and Contractors' Ass'n.) C. A. B. 1913, pp. 187-191. Eng. News, 1910-II-492; Comments, same Vol. p. 540.

Earth measurement clause. A lawsuit involving same. What first appears to have no ambiguity, is shown to have different interpretations. Eng. News, Vol. 51, Mar. 10, 1904, p. 227.

Measuring quantity excavated under water. United States Engineer Corps. Johnson, p. 128.

Also see "Excavation."

Oils, Bituminous and Creosote—

Specifications for Coal Tar Creosote for Wood Block Pavements of Chicago, by John Ericson. Eng. Cont., Jan. 17, 1912, p. 72.

Specifications and Analysis of Creosote Oil, by S. R. Church. Discussion of, for timber preservative. Eng. Rec., 1912-I-80.

Specifications for coal tar creosote. A. R. E. & M. W. Ass'n. Eng. Cont., Sept. 30, 1908, p. 204.

Specifications for road oil, San Joaquin Co., Cal. W. B. Hogan. Eng. Cont., Aug. 5, 1914, p. 129.

Specifications for residuum oil for road treatment of St. Louis, Mo. Eng. Cont., Mar. 23, 1910, p. 268.

Specifications for analysis of coal tar creosote. Committee Report. A. R. E. & M. W. Ass'n, Vol. 9, 1908, p. 708; Vol. 12, 1911, p. 743.

Standard specifications for coal tar creosote. Committee Report. A. R. E. & M. W. Ass'n, Vol. 11, 1910, p. 737.

See also "Pavements."

Oil, Fuel—

Specifications for, in signal lamps. Eng. News, 1906-II-431.

Fuel. Specifications for purchase. U. S. Bureau of Mines. Eng. News, 1911-II-205.

Fuel Oil Specifications and Corrections from Fuel Economy Tests at a Large Oil Burning Electric Power Plant, by C. R. Weymouth. A discussion of requirements and results. Trans. A. S. M. E., Vol. 30, 1908, p. 775.

Oil, Fuel—Continued.

Fuel Specifications and Contracts. Discusses desirability of specifications by Wm. D. Ennis. Eng. Rec. Vol. 57, p. 554.

Specifications for Fuel for Heavy-oil Engines. Abstract of bulletin of U. S. Bureau of Mines by I. C. Allen. Can. Eng. Vol. 25, p. 289.

Oil, Linseed—

Standard specifications for purity of raw linseed oil from North American seed. Proc. Am. Soc. Test. Mat., Vol. 13, 1913, p. 399.

Oil, Lubricating—

Necessary reform in specifications for lubricating oils. Paper before Am. Soc. Test. Mat., by Dr. A. Sommer. Eng. Rec., 1910-II-167.

Requirements for lubricating oil in combustion engines. Dr. A. Sommer. Proc. Am. Soc. Test. Mat., Vol. 10, 1910, 466.

Oils. Abstract of Pennsylvania railroad specifications for materials. (In practical use for several years. Reprint rec. by Soc. of Automobile Engineers Standard Committee, 1911.) Reference: Trans. of the Soc. of Automobile Engineers, Vol. 6, pp. 400-445.

Specifications for Auto Engine Lubricating Oil, by Henry Souther, Chm. Standards Comm. for Soc. of Automobile Eng., 1910. Reference: Trans. of the Soc. of Automobile Engineers, Vol. 5, pp. 168-175. Note: For notes and instructions referring to above, see same Vol., pp. 176-202.

Paint—

Specification proposed by American Society for Testing Materials. Tests of. Eng. News, 1911-II-35, 64.

Specifications for paint for steel terminal structures, Pennsylvania railroad, New York. Trans. A. S. C. E., Vol. 69, p. 213 (1910).

Preservative coatings. Standard specifications adopted by American Society for Testing Materials. One specification in 1913 Year Book, pp. 287-289. Note: Above Year Book contains all standard specifications of the society, about sixty-three or sixty-four in number, latest revision. Also classified list giving dates of adoption and subsequent revision.

Paints. Abstract of Pennsylvania railroad specifications for materials. (In practical use for several years. Reprint rec. by Soc. of Automobile Engineers Standard Committee, 1911.) Reference: Trans. of the Soc. of Automobile Engineers, Vol. 6, pp. 400-445.

Paper—

New specifications of Government printing office. Eng. News, 1912-I-490.

Pavements and Road Construction, General—

General specifications for Michigan state reward roads. Third biennial report of the State Highway Commission (Dec. 1, 1908, to June 30, 1910). Class A. Clay gravel roads, pp. 68-71; Class B. Gravel roads, pp. 71-74; Class C. Stone gravel roads, pp. 74-76; Class D. Gravel stone roads, pp. 77-79; Class E. Stone roads. pp. 79-83.

Pavements and Road Construction, General—*Continued.*

Standard specifications adopted by the American Society for Testing Materials. Seven specifications in 1913 Year Book, pp. 290-299.

Note: Above Year Book contains all standard specifications for the society, about sixty-three or sixty-four.

Paving. Standard specifications for rattler and rattler test. (Recommended by the Nat'l Paving Brick Mfgs. Ass'n, 1911.) Will P. Blair, secretary, Cleveland, O. Municipal Eng., Vol. 40, pp. 93-95.

Specifications for Street Railway Pavements, by Whinery (McGraw-Hill Book Company). General, pp. 13-22; foundations, pp. 24-31; sheet asphalt pavement, pp. 33-45; asphalt block pavement, pp. 46-48; granite block pavement, pp. 50-55; brick pavements, pp. 56-60. (Differs only in minor details from those of Ass'n for Standardizing Paving and Nat'l Paving Brick Mfg. Ass'n.)

Maintenance. Simple clause, no absurd requirements, discussion of good and bad points of same. Eng. News, Sept. 3, 1903.

Materials for road construction and standards for their test and use. Proc. A. S. C. E., Apr. 1915.

Standard specifications of the Association for Standardizing Paving Specifications. (Reports of various committees adopted.)

- (1) Specifications for concrete sidewalks, second annual report of association, pp. 35-37.
- (2) Specifications for concrete curb and combined curb and gutter, second annual report association, pp. 37-40.
- (3) Specifications for concrete for pavement foundations, second annual report of association, pp. 40-42.
- (4) Specifications for concrete pavements, second annual report of association, pp. 42-45.
- (5) Specifications for macadam, second annual report of association, pp. 50-52.
- (6) Specifications for creosoted wood blocks report of association, pp. 54-56.
- (7) Specifications for analysis of coal tar creosote (appendix to specifications No. 6), second annual report of association, pp. 57-59.
- (8) Brief specifications for brick and granite block, first annual report of association, pp. 63-66.
- (9) Specifications or sheet asphalt pavement, first annual report of association, pp. 73-78.
- (10) Specifications for bituminous concrete pavement, first annual report of association, pp. 78-82.

Specifications for Street Railway Pavements, by Whinery (McGraw-Hill Book Co.). Wood block pavement, pp. 62-68; bituminous concrete pavements, pp. 69-73; hydraulic concrete pavement, pp. 73-77; experimental or untried pavement, pp. 78-80; concrete curb and gutter, pp. 80-84; concrete sidewalks, pp. 84-88.

Pavement specifications in use in different cities and states. References: Chicago specifications in use during 1905. See Engi-

Pavements and Road Construction, General—*Continued.*

- neering Work in Towns and Cities, by McCullough, p. 68. Specifications in use in other cities, see above work, pp. 67-91; also Civil Engineers' Pocket Book, by Frye, p. 1101. Highway Eng. and Hand Book, by Harger & Bormey, p. 310.
- See annual reports of the Association for Standardizing Paving Specifications. John B. Hittell, Secy-Treas., 5917 Winthrop Ave., Chicago. 1910 and 1911 (1st and 2d) annual reports in engineering library.
- Standard specifications for state aid roads in New Jersey. Extracts from revised specifications; also discussion of methods and experience of commission. Municipal Engineering, Vol. 20, May, 1901, pp. 294, 295.
- Street paving. General instructions to inspectors by Bureau of Highways of the Borough of Manhattan, New York City. Eng. News, Vol. 69, p. 1114.
- State road construction in Wisconsin. Instructions for foremen and contractors. Eng. News, Vol. 70, p. 291.
- Highway work for New York state; new specifications for. Eng. News, Vol. 70, p. 1203.
- Suggested standard specifications for macadam, brick, granite block, creosoted wood block and concrete pavements. Convention of Chicago city officials. Eng. Cont., Mar. 9-16, 1910, pp. 222-243.
- Specifications for asphalt, brick, macadam and wood block pavements. Recommended for Chicago by Samuel Whinery. Eng. News, 1911-I-471.
- Chicago bureau of public efficiency specifications for pavements, covering wood block and oil preservative, asphalt, brick and granite block. Eng. News, 1911-I-254.
- New York state highway work. Eng. News, 1913-II-1203.
- Recent specifications and standards of Maine Highway Commission. Abstract of general specifications (staff article). Eng. Cont., Sept. 16, 1914, p. 277.
- Important features of new standard paving. Specifications of Pittsburgh department of public works. Eng. News, June 25, 1914, p. 1435.
- Roadway standards of department of public works, city of Pittsburgh, Pa. Eng. Cont., Aug. 21, 1912, p. 205.
- Standard plans and specifications for paving, Seattle, Wash. Eng. Cont., Aug. 9, 1911, p. 150.
- Requisites for Successful Pavement, by S. Whinery. Eng. News, 1908-II-281.
- Richmond, Indiana, Abstracts from Specifications, by H. L. Weber. Eng. News, 1905-I-215; 1905-I-598.
- Specifications for Roads of Different Types. Specifications of York Co., Ontario. E. A. James. Can. Eng. Vol. 24, p. 103.

Pavements, Bituminous—

- Asphaltic concrete, bituminous macadam, brick, etc., of Pennsylvania highway department. Eng. Cont., Aug. 19, 1914, p. 189.
- Asphalt and bituminous concrete pavements in Washington, D. C. Specifications for all Materials and Work, by Capt. Mark Brooke. Eng. Cont., Jan. 10, 1914, p. 679.
- Asphalt block pavement at Washington, D. C. Eng. Cont., Dec. 21, 1910, p. 554.
- Bituminous concrete specifications. Adopted by Chicago convention. Eng. News, 1910-I-309
- Specifications for bituminous surface concrete pavement in Los Angeles Co., Cal. Eng. Cont., Nov. 6, 1912, p. 513.
- Specifications of New York state highway department for bituminous macadam and bituminous materials. Eng. Cont., Dec. 8, 1909, p. 490.
- New Jersey standard specifications for asphaltic concrete. Eng. Rec., 1912-II-340.
- Criticism of Massachusetts Specifications, Confusion as to Asphaltic, by H. Tipper. Eng. News, 1909-II-375; same, by H. W. Clark. Eng. News, 1909-II-521.
- Asphalt paving. (Report of commissioner of accounts of the city of New York, Feb. 3, 1904.) Specifications and their discussion, pp. 1-62; Practical use and value of specifications, pp. 67-70.
- Standard specifications for sheet asphalt pavements, city of New York. Reference: Highway Engineering, by Morrison, pp. 233-274.
- Asphaltic concrete and sheet asphalt pavements—specifications for, at Vancouver, B. C. Eng. News, Vol. 68, p. 770.
- Asphalt pavement—new Harlem bridge at One Hundred Fifty-fifth St., New York. Johnson, p. 171.
- Standard specifications for sheet asphalt. (Adopted by the Amer. Soc. of Municipal Improvements, Sept. 27, 1911.) References: Proc. of the Annual Convention of the Amer. Soc. of Municipal Improvements. (In pamphlet form by Municipal Journal, 50 Union Square, New York.)
- Asphaltum pavement. Johnson, p. 166.
- Vancouver, B. C., specifications for sheet asphalt and asphaltic concrete. Eng. News, 1912-II-770.
- English Suggestion for Standard Specifications for Bituminous Bound Road Surface, by J. S. Brodie. Eng. Cont., Oct. 2, 1912, p. 376.
- Tar Concrete Pavements in Ontario, by W. A. McLean. Eng. Cont., Jan. 2, 1912, p. 14.
- Specifications for oil-cement-concrete pavements, New York City. Eng. Cont., July 24, 1912, p. 97.
- Maintaining Concrete Roads with Bituminous Wearing Surfaces, by H. C. Poore. (Specifications for applying bituminous surface.) Eng. Cont., Jan. 7, 1914, p. 17.
- Binder Course in Bituminous Pavements, by F. N. Bingham. Eng. News, 1913-I-1079.

Pavements, Bituminous—Continued.

Oil Graveled Streets; Specifications, Los Angeles, Cal., by N. Ellery. Eng. News, 1907-I-366.

Specifications of the New York state highway department for bituminous macadam, 1909. Engineering and Contracting, Vol. 32, 1909, pp. 490, 491.

Specifications for tar macadam pavement. Specifications for macadam roadways as constructed in various cities of Ontario, Canada. Also some discussion of materials and costs. Municipal Engineering, Vol. 20, June, 1901, pp. 370-372.

Suggested standard specifications for asphalt and bituminous pavements. By convention of Chicago city officials. Eng. Cont., Mar. 23, 1910, p. 270.

Ottawa, Ontario, Specifications for Tar Macadam, by N. J. Ker. Eng. News, 1906-II-213.

San Monica, California, Oiled Dirt Roads; Asphaltic Oil and Fitzgerald Tamper Roller, by E. H. Wilcox. Eng. News, 1907-I-366, and 1907-I-543.

Bituminous macadam specifications may be obtained from: Indianapolis, Ind.; Mankato, Minn.; Knoxville, Tenn.; Moline, Ill.; Warren Bros. Co., Boston, 59 Temple St.; The Indian Refining Co., New York, 115 Broadway, and other companies.

Indianapolis specifications for bituminous macadam pavement. Municipal Engineering, Vol. 37, 1909, pp. 261, 262.

Pavement, Brick and Block—

Brick paving construction. Instructions issued by Nat. Paving Brick Mfgs. Ass'n. W. J. Blair. Eng. News, 1906-II-231, 234.

Brick and granite block specifications adopted by Chicago convention. Eng. News, 1910-I-291.

Specifications for Slag Foundations for Brick Pavement, Niles, Ohio, by Wm. V. Alford. Eng. News, May 7, 1914, p. 1014.

Standard specifications for brick pavements. (Adopted at the 16th annual convention of the National Paving Brick Manufacturers' Association.) References: Engineering Work in Towns and Cities, by McCullough, p. 64. Note: Copies of same can be secured through Will P. Blair, Secy., Cleveland, O.

Paving brick tests by American Brick Manufacturers' Association. Johnson, p. 161.

Standard specifications for brick pavements. (Adopted by Amer. Soc. Municipal Improvements, Sept. 27, 1911.) References: Proc. of the Annual Convention of the Amer. Soc. of Municipal Improvements. Issued in pamphlet form by the Municipal Journal, 50 Union Square, N. Y.

Brick paving, city of St. Louis. Johnson, p. 163.

Granite pavement, city of Milwaukee. Johnson, p. 173.

Method and specifications of constructing wood block pavement at Grand Forks, N. D. Paper before Ill. Soc. of Eng. & Surv., by J. J. Smith. Eng. Cont., Oct. 27, 1909, p. 353.

Pavement, Brick and Block—Continued.

English Specifications for Construction of Wood Block Pavement, by Clifford Richardson. Eng. Cont., May 29, 1912, p. 608.

Vancouver, B. C., wood block pavement. Eng. News, 1911-II-475.

Wood block—specifications adopted by Chicago convention. Creosoted block. Eng. News, 1910-I-290.

Paving. A comparison of the specifications for creosoted wood paving blocks of fourteen American cities. Published paper by C. Marshall Taylor, Chemist of the International Creosoting & Construction Co. of Galveston, Tex. Also see discussion and table, Engineering-Contracting, 1910, Vol. 33, p. 552.

New Specifications for Creosote-Wood Block Pavement by Bd. of Local Improvement Chicago, Ill. Can. Engr. Vol. 23, p. 250.

Pavement, Concrete—

Concrete Roads in Milwaukee Co., Wis., by A. J. Kuelling. Eng. Cont., May 13, 1914, p. 551.

Specifications for concrete pavements of R. S. Blome & Co., Chicago. Eng. Cont., Dec. 16, 1908, p. 415.

Standard specifications for Portland cement roads and Portland cement sidewalks. Nat. Ass'n of Cement Users. Eng. Cont., Jan. 20, 1909, p. 53.

Concrete specifications adopted by Chicago convention for sidewalks, curbs and pavements. Eng. News, 1910-I-308.

Concrete pavements. Foundations; paving practice. G. C. Warren. Eng. News, 1909-II-611.

Pavement, Macadam and Earth Roads—

Specification and notes, on macadam road construction. Paper before W. S. E., by A. N. Johnson. Eng. Cont., Oct. 28, 1908, p. 276.

Details and specifications of California highway commission—macadam. Eng. Cont., July 3, 1912, p. 15.

Macadam specifications adopted by Chicago convention. Eng. News, 1910-I-290.

Specifications for Shell Roads, by Maj. W. W. Crosby of state road commission, Md. Eng. Cont., Jan. 3, 1912, p. 11.

Earth roads, sand, clay, gravel, chert and bridges, culverts, etc. Alabama state highway commission. Eng. Cont., Nov. 25, 1911, p. 504.

Specification for trunk line highway in Michigan (staff article). Eng. Cont., Feb. 24, 1915, p. 162.

Specifications for Macadam Roads, by H. P. Gillette, A. I. Frye. Eng. News, 1901-II-351.

Specifications for Macadam Roads, by E. McCullough. Eng. News, 1903-I-189; 1904-II-241.

Standard state aid specifications for stone roads—New Jersey. Reference: Highway Engineering, by Morrison, pp. 126-142.

Macadamizing. Fairmount Park, Phil. Haupt, p. 149.

Piles—

Specifications A. R. E. & M. W. Ass'n. Eng. News, 1904-I-264.

Piles—Continued.

Specifications for creosoting at Pacific Creosoting Co. Eng. News, 1910-II-432.

Notes on a Rational Specification for Wooden Pile, by E. P. Goodrich. Eng. Cont., May 19, 1915, p. 456.

Concrete pile specifications for Point Bridge at Pittsburg. Eng. Record, 1913-II-581 and 646.

See also "Bridges and Trestles, Timber."

Pipe, Accessories—

Pipe flanges. New standards of Am. Soc. Mech. Engrs. Eng. News, 1912-II-121, 338.

Burlap wrapping steel pipe. Eng. News, 1913-II-1083.

Pipe, Laying and Cleaning—

Pipe laying. Seattle standard specifications adopted. H. L. Estep. Eng. News, 1910-I-557.

Laying sewer pipe. St. Louis specifications for pipe sewers. Art. 139, Johnson, p. 186.

Laying water pipe. Water commissioner of St. Louis. Johnson, p. 198.

Specifications for Cleaning Water Mains at Hartford, Conn., by C. M. Saville. Eng. News, 1913-II-1098.

Pipe, Cast Iron—

Standard specifications for cast iron pipe and special castings. (Adopted May 12, 1908, by the Amer. Water Works Ass'n.) References: Proc. Am. Water Wks. Ass'n, 1908, p. 771. Civil Engineers' Pocket Book, by Frye, p. 1239. In pamphlet form, address J. M. Diven, Secy. A. W. W. A.

Standard specifications for cast iron pipe and special castings. (Adopted 1902, by the New England Water Wks. Ass'n Comm. appointed in 1912 to revise same.) References: Journal New England W. W. Ass'n, Vol. 16, pp. 335-358; also Vol. 17, p. 84; catalogue "Cast Iron Pipe," pub. by U. S. Cast Iron Pipe & Foundry Co., Western Office, 638 The Rookery, Chicago. Note: Copies of New England W. W. Ass'n specifications available in pamphlet form. Address 715 Tremont Temple, Boston, Mass.

Water pipe. Reports of N. Eng. W. Wks. Ass'n for cast iron pipe. Eng. News, 1901-II-216, 224, 435, 469; 1902-II-193, 211, 212.

Standard specifications for cast iron pipe and special castings. Proc. Am. Soc. Test. Mat., Vol. 4, 1904, p. 57.

Standard specifications for cast iron pipe and special castings. Proc. Am. W. Wks. Ass'n, 1908, p. 770.

Standard Plans and Specifications for Water Mains, Seattle, Wash., by R. H. Thomson. Eng. Cont., Aug. 2, 1911, p. 127.

Proposals for international export specifications for cast iron pipe and fittings. Am. Soc. Test. Mat., Vol. 14, 1914, p. 157.

Cast iron. St. Louis water department. Johnson, p. 219.

Pipe, Cast Iron—*Continued.*

Cast iron water pipe. Water Works System of Cincinnati. Johnson, p. 221.

Manufacture and delivery of cast-iron water pipe. City of Rochester, N. Y. Johnson, p. 190.

Pipe, Concrete—

Specifications for Concrete Sewer Pipe at Bellingham, Wash., by H. A. Whitney. Eng. Cont., Feb. 8, 1911, p. 157.

Concrete Sewer Pipe Tests in Kansas City, by E. S. Wallace. Eng. News, Vol. 69, p. 568, 1913.

Specifications for reinforcement of concrete culvert pipe, Illinois Central Railroad. Proc. of the 22nd Annual Convention of the Amer. Ry. Bridge & Building Ass'n, pp. 103-107.

Proposed standard specifications for concrete drain pipe and tile. (Submitted by Comm. of the Nat. Ass'n of Cement Users in 1911.) Reference: Proc. of the Nat. Ass'n of Cement Users, Vol. 7, pp. 761-765.

Proposed standard specifications for plain concrete drain tile. Committee reported to Nat. Ass'n Cement Users. Eng. Cont., Feb. 23, 1910, p. 167.

See also "Concrete."

Pipe, Steel—

Lead Lined Steel Tubing, United States Navy, by R. D. Gatewood. Description and notes. Eng. News, 1912-I-896.

Portland, Oregon, Riveted Steel Pipe, by J. C. Stevens. Eng. News, 1911-II-112.

Riveted steel water pipe. Water supply of Cambridge, Mass. Johnson, p. 225.

Pipe, Vitrified—

Sewer pipe—Iowa State Drainage Ass'n. Adopted Feb., 1913. Eng. Rec., 1913-I-235.

Specifications for Sewer Pipe, Vitrified Pipe and Pipe Laying in St. Louis, by W. W. Horner. Eng. Cont., Sept. 13, 1911, p. 286.

Specifications for drain tile and sewer pipe. Report of Committee of Iowa State Drainage Ass'n. Adopted Feb., 1913. Eng. Rec., 1913-I-235.

Proposed standard specifications and recommended practice for drain tile and tile drain construction. Report committee to Am. Soc. Test. Mat. Eng. Cont., Aug. 19, 1914, p. 181.

Drain tile. Standard specifications Iowa State Drainage Ass'n. Exp. Sta. Iowa State College, Ames, Ia. Eng. News, 1913-I-484.

Tentative standard specifications for drain tile, sewer pipe and for pipe laying. 1913, Printed for Distribution by Engineering Exp. Sta., Iowa State College. Write Director, A. Marston, Ames, Ia. Eng. Rec., Vol. 67, pp. 235, 236.

Drain tile and sewer pipe. Specifications for—committee report of Iowa State Drain. Ass'n. Eng. Rec., Vol. 67, p. 235.

Sewer pipe. Johnson, p. 183.

Pipe, Wood Stave—

- Specifications for wood stave pipe, Atlantic City, N. J. Eng. Cont., Oct. 30, 1912, p. 488.
- Design and specifications of Sacramento water supply wood pipe line, El. Paso & S. W. Ry. Co. Eng. Cont., July 17, 1912, p. 70.
- Wood stave pipe. United States Reclamation Service, by E. A. Moritz. Eng. News, 1912-I-571, 799.
- Specifications for Wood Stave Pipe, by A. Swickard. Eng. Cont., Jan. 6, 1915, p. 14.
- Specification for a standard wood pipe line designed for a pressure of 80 pounds—Proc. of the 32nd annual convention of the Amer. Ry. Bridge & Building Ass'n, pp. 126-129.
- Wooden stave pipe used in California Johnson, p. 232.

Plans—

- Rules for sewerage and water supply plans, submitted to N. J. State Bd. Health. Eng. News, 1913-II-548.
- See also "Maps."

Plastering—

- Standard specifications for Exterior Plastering (Stucco). Pamphlet Aug., 1913, of Associated Metal Lath Manufacturers, Youngstown, Ohio.

Plumbing—see "Building."**Pumping Machinery—**

- Selection and Specifications for Water Wks. Pumping Machinery, by N. J. Hill. Eng. Rec., 1905-II-39.
- Specifications for Vertical Triple Expansion Pumping Engine, Milwaukee, Wis., by C. T. Myers. Proc. Am. W. Wks. Ass'n, 1909, p. 77.
- Specifications for Irrigation Pumping Plant, Payette, Idaho, by G. T. Ingersoll. Eng. Cont., Oct. 2, 1912, p. 385.
- Specifications for sewage pumping plant near Duluth, Minn. Eng. Cont., April 7, 1915, p. 309.
- Pumps to be operated by water power. Austin, Texas. Johnson, p. 247.
- Large pumping engines. City of St. Louis. Johnson, p. 266.
- Water works. Wilmington, Delaware. M. C. Conwell, Consulting Engineer. Haupt, p. 104.

Rails—see "Iron and Steel—Rails."**Railways—**

- Specifications for railroad work that are specific and fair. Eng. News, 1905-I-258.
- Roadway specifications for clearing, grubbing, grading, etc. A. R. E. & M. W. Ass'n, 1903, Vol. 4, p. 19.
- Tunnel excavation. A. R. E. & M. W. Ass'n, 1905, Vol. 6, p. 125.
- General specifications for modern steam shovel roadway construction. Committee report. A. R. E. & M. W. Ass'n, 1907, Vol. 8, p. 298.

Railways—Continued.

Proposed amendments of recommended standard definitions. (Proposed by Comm. of Amer. Ry. Eng. & Maintenance of Way Ass'n, 1910.) Reference: Proc. of Ass'n, Vol. 11, Part 1, p. 178.

Superstructure and track laying. Haupt, p. 155.

Grading and masonry of a single track railroad—Philadelphia & Reading railroad. Haupt, p. 150.

Railway road-bed. Amer. Soc. of Civil Engineers. Johnson, p. 345.

Specifications for formation of road-bed. Eng. News, 1903-I-259, 280; 1901-I-214.

Specifications for grading. Rept. Am. Ry. Eng. & M. W. Ass'n. Eng. News, 1901-I-199.

Specifications for standards of track construction in United States, Canada and Mexico. Eng. News, 1900-II-142, 148, 215, 430.

Specifications for track tanks for supplying water to tenders. Specifications of Am. Ry. Eng. Ass'n. Eng. News, 1911-I-410.

See also "Ballast;" "Cars;" "Excavation;" "Frogs;" "Locomotive;" "Steel Rails;" "Timber Ties;" "Tires."

Refractory Material—

Standard Specification for Refractory Material. Covers silica brick, block and tile adopted by Inst. Gas. Engrs. of Gt. Britain. Can Engr. Vol. 23, p. 331.

Reservoirs—

Specifications for asphalt lining for reservoirs. Eng. News, 1896-I-164.

Specifications for Reinforced Concrete Settling Basins, by Alex. Potter. Proc. Am. W. Wks. Ass'n, 1912, p. 113.

Concrete reservoir lining at Aurora, Ill. Eng. News, 1902-I-423.

Retaining Walls—

Specifications for retaining walls. Trans. A. S. C. E., Vol. 48, p. 486 (1902).

River Improvement—see "Harbor and River Improvements."**Roads—see "Pavement and Road Construction."****Rock—**

Definition from specifications of Chicago board of local improvements. Eng. News, 1911-I-683.

Specifications for tests of road building rock. Am. Soc. for Test. Mat. Eng. Cont., Aug. 5, 1908, p. 87.

Extracts from specifications for concrete stone for Catskill aqueduct buildings. Paper before Am. Conc. Inst., by H. L. Rogers, Eng. Cont., April 14, 1915, p. 340.

Specifications for stone, C., M. & St. P. Ry. Johnson, p. 143.

Roof—

Galvanized iron for tropical climate. R. M. Beaufield. Eng. Cont., Nov. 20, 1912, p. 586.

See also "Building."

Sand—

- Moulding sand. J. I. Case Co. Eng. News, 1902-II-185.
Specifications for sand for concrete aggregate, based on tests made at Univ. of Illinois. C. C. Wiley. Eng. Rec., Apr. 11, 1914, p. 419.
Sand. Concerning specifications for Editorial comments. Believes there is no justification for the ordinary brief requirement "Clean Sharp Sand." Eng. News, Vol. 53, Feb. 2, 1905, pp. 125, 126.
Sand—Filter. Albany water filtration plant. Johnson, p. 294.
Selection of Sand for Concrete Grades and Methods of Testing Sand. Staff article, Const. News, Nov. 29, 1913.

Sanitation—

- Specifications for sanitary precautions. Camp sanitation, Catskill aqueduct construction camp. A. W. Tidd. Eng. News, 1913-II-752.

Sewage Screens—

- Specifications for sewage screen. Daytona, Fla. Eng. Cont., Dec. 2, 1914, p. 525.

Sewers, General—

- Commendable specifications. Eng. News, 1905-II-148.
Indefinite specifications. Alex. Potter. Eng. News, 1905-I-603.
Sewer specifications proposed for criticism. Eng. Rec., 1910-I-227, 287.
A Discussion of Sewer Specifications, by Gen'l Contractors' Ass'n. Eng. Rec., 1910-I-25.
Specifications for limits of excavation for sewers at Pittsburg, Pa. Eng. Cont., Aug. 14, 1912, p. 188.
Unusual clauses in sewer specifications. Eng. News, 1904-II-268, 544.
Specifications for the Construction of Sewers at Clinton, Ia., by Chas. C. Brown, Engineering World, Vol. 4, 1906, pp. 490-492.
Outline for standard sewer specifications. (Report to the Amer. Soc. of Municipal Improvements, 1912.) Municipal Engineering, Vol. 42, 1912, pp. 90-92.
Sewer specifications. Written by six well recognized engineers. Pamphlet, published by the Clay Products Publicity Bureau, Kansas City, Mo.
Main sewer. City of Philadelphia, Pa. Samuel L. Smedley, Chief Engineer. Haupt, p. 90.

Sewers, Brick—

- Brick sewer specifications, New York. Eng. News, 1902-I-200.
Brick and tile sewers. Used in the city of St. Louis. Johnson, p. 178.
Specifications for Vitrified Pipe and Brick St. Louis, by W. W. Horner. Eng. Cont., Sept. 13, 1911, p. 286.

Sewers, Concrete—

- Concrete and steel storm water sewer and remarks on specifications. Eng. Cont., Nov. 3, 1909, p. 376.

Sewers, Concrete—Continued.

Plans and specifications for sewer catch basins, concrete and brick sewers and appurtenances, Pittsburg, Pa. Eng. Cont., July 17, 1912, p. 72.

Plans and Specifications for Concrete Sewer Manholes at Hamilton, Ill., by L. P. Wolff. Eng. Cont., May 15, 1912, p. 559.

Brooklyn specifications for reinforced concrete, triple outlet sewer, wharf construction. Eng. News, 1903-I-8.

Sewers, Vitrified—

Vitrified tile house drains. Chicago plumbing ordinance. Eng. News, 1905-II-458; 1906-I-387.

Standard Plans and Specifications for Sewers, Seattle, Wash., by R. H. Thomson. Eng. Cont., July 26, 1911, p. 99.

Specifications for drain tile and sewer pipe and laying. Iowa State Drainage Ass'n. Eng. Rec., 1913-I-235.

See also "Pipe, Vitrified."

Sidewalks, Curb and Gutter—

Standard specifications Nat. Ass'n of Cement Users. Eng. News, 1909-I-344; Eng. Cont., Jan. 20, 1909, p. 52.

Proposed standard specifications for Portland cement curb and gutter. Report to Nat'l Ass'n Cement Users. Eng. Cont., Feb. 23, 1910, p. 177.

Standard Plans and Specifications for Sidewalks, Seattle, Wash., by R. H. Thomson. Eng. Cont., July 12, 1911, p. 36.

Standard specifications for Portland cement sidewalks. (Adopted Jan., 1908, by Nat. Ass'n of Cement Users, Phila., Pa.) References: Civil Engineering Pocket Book, by Frye, p. 1117; Engineering Work in Towns and Cities, by McCullough, p. 35.

For specifications for cement sidewalk, curb and gutter, see Hand Book for Cement Users (\$3.00). Municipal Eng., 28 S. Meridian St., Indianapolis, Ind.

Specifications for concrete, granite and blue stone curbs, City of Dover, Del. Municipal Engineering, Vol. 37, 1909, pp. 186, 187.

Granitoid sidewalks, St. Louis. Johnson, p. 174.

Specifications for Portland cement sidewalks. Prescribed for Dept. of Public Works, Pittsburg, Pa. Municipal Engineering, Vol. 19, July, 1900, pp. 16-18.

Sieve—

Cement Sieve Specifications, by R. Y. Ferner. Work of Bureau of Standards. Eng. Rec., 1912-II-728.

Signals—

Standard specifications for mechanical interlocking and materials for construction work. Covers all details of mechanical signals. (Adopted by Ry. Signal Ass'n.) A. R. E. & M. W. Ass'n, 1905-6-519; 1906-7-491; 1907-8-73.

See also "Wire."

Soap—see "Chemicals."

Spelter—see "Zinc."

Standpipe—see "Tanks and Standpipes."

Steam Engines—

Westinghouse Elect. & Mfg. Co. Requirements for Parallel Operation of Alternators, by E. M. Tingley. Eng. News, 1902-I-498.

Specifications for installation, Engine Bldrs. Ass'n. Eng. News, 1901-I-457.

Specifications for steam engines. Editorial comment. Essential requirements, not in great detail. Engineers sometimes unfair, etc. Eng. Rec., Vol. 39, April 1, 1899, pp. 393, 394.

Engines, New Orleans, La. Johnson, p. 404.

See also "Steam Plant."

Steam Plant—

Specifications for power plants. (Arranged in fourteen sections.)

Engineering Magazine Co. Reference: Engineering Catalogues and Specifications (Power Plant Edition), 1913, Specification Digest.

- (1) General Clauses, p. 19.
- (2) Boilers & Stacks, p. 21.
- (3) Gas Producers, p. 27.
- (4) Steam Fitting, p. 29.
- (5) Turbines, p. 40.
- (6) Steam Engine, p. 45.
- (7) Internal Combustion Engines, p. 49.
- (8) Dynamos, p. 52.
- (9) Electric wiring, p. 54.
- (10) Switchboards, p. 60.
- (11) Storage Battery, p. 61.
- (12) Refrigeration, p. 63.
- (13) Fuel, p. 66.
- (14) Lubricants & Lubrication, p. 67.

Specifications for the new waterside power house of the New York Edison Company. Book published by the New York Edison Co., 1907. Includes specifications for the following:

- (a) Bulkhead and condensing Water Tunnels, pp. 5-11.
- (b) Foundations, pp. 11-21.
- (c) Structural Steel & Iron Work, pp. 22-45.
- (d) Superstructure, pp. 46-153.
- (e) Coal and Ash Handling Machinery, pp. 154-168.
- (f) Cranes, pp. 169-184.
- (g) Boilers and Superheaters, pp. 185-195.
- (h) Boiler Fronts, pp. 196-199.
- (i) Grates, pp. 200-203.
- (j) Economizers, pp. 217-220.
- (k) Forced Draft Apparatus, pp. 204-219.
- (l) Feed Pumps, pp. 221-236.
- (m) Turbo Generators, pp. 237-254.

Steam Plant—Continued.

(n) Condensers, pp. 254-300.

(o) Piping, pp. 301-347.

(p) Storage Battery Plant, pp. 348-354.

(q) Electrical Apparatus, pp. 355-402.

Steam plant of a small electric light station, engine and attachments.

Johnson, p. 240.

Steam Plant Auxiliaries—

Economizers, New Orleans, La. Johnson, p. 413.

Condensers and pumps, New Orleans, La. Johnson, p. 411.

See also "Steam Plant."

Steel—see "Iron and Steel."

Stone—see "Rock."

Surveys—

Specifications for surveys at Swathmore, Pa. Eng. News, 1894-II-13.

Switchboard—see "Electric Railway."

Tanks and Standpipes—

Suggested specifications for reinforced concrete water tanks for railway water supply. Eng. Cont., Apr. 12, 1911, p. 416.

The Need of More Care in the Design and Construction of Elevated Tanks, by W. O. Teague. Abstract of specifications for wood and steel elevated tanks. Trans. A. S. M. E., Vol. 35, 1913, p. 920.

Specifications for water tanks. (Submitted and recommended as good practice by a committee of the A. R. E. & M. W. Ass'n, 1910.)

Reference: Proc. of Ass'n, Vol. 11, part 2, pp. 1144-1154.

Material and Workmanship of a Steel Standpipe, by Wm. D. Pence. Johnson, p. 235.

Specifications for Standpipes, by Wm. L. Pence. Outline of tendencies of standpipe specifications. Review of qualities of materials and workmanship. Eng. News, Vol. 33, Feb. 28, 1895, pp. 130-134.

Specifications for a reinforced concrete tank at Dandenong, Victorian railways, New South Wales, Australia. Proceedings of the 22nd annual convention of the Amer. Ry. Bridge & Building Ass'n, pp. 78-82.

Discussions of Standpipe Specifications, by W. C. Parmley. Eng. News, 1894-I-392, 431.

Discussions of Standpipe Specifications, by W. D. Pence. Eng. News, 1895-I-130-136, 289-354.

Specifications for standpipe at Peoria Ill. Eng. News, 1894-I-286.

Specifications for standpipe at Schenectady, N. Y. Eng. News, 1895-I-354.

General design and specifications for elevated structural steel tower and tank for Hamilton, Ill., L. P. Wolff. Eng. Cont., June 19, 1912, p. 702.

Telephone Line—see "Transmission Line;" "Wire."

Tile, Building—

Specifications Proposed for Hollow Clay Tile Building Blocks, by V. G. Marani. Eng. News, 1912-I-248, 1912-II-629.

Hollow clay tile building blocks end constructions. Eng. News, 1912-II-1016.

See also "Buildings."

Tile, Drain—see "Pipe—Vitrified;" "Sewers."**Timber, Poles—see "Transmission Line."****Timber, Structural—**

Bridge timber—Report A. R. E. & M. W. Ass'n. Eng. News, 1905-I-323.

Nomenclature and specifications for structural timber. Am. Soc. Test. Mat. Eng. Rec., 1907-I-771.

Standard specifications for structural timber. Proc. Am. Soc. Test. Mat., Vol. 7, 1907, pp. 181-187.

Standard specifications for yellow pine bridge and trestle timber. Proc. Am. Soc. Test. Mat., Vol. 10, 1910, p. 159.

Specifications and grading rules for Douglas Fir timber. An analysis of Forest Service tests on structural timber. Proc. Am. Soc. Test. Mat., Vol. 11, 1911, pp. 182, 183, 878.

Douglas fir. Grading and specifications. Eng. News, 1911-II-373, 380.

Standard Plans and Specifications for Timber Trestles, Seattle, Wash., by R. H. Thomson. Eng. Cont., Aug. 30, 1911, p. 243.

Specifications for Factory Timbers, by F. J. Hoxie. Trans. A. S. M. E., Vol. 35, 1913, p. 526.

Specifications for structural timber. Committee report. A. R. E. & M. W. Ass'n, 1905-6-32.

Specifications for bridge and trestle timber and piling. Committee report. A. R. E. & M. W. Ass'n, 1906-7-685.

Standard specifications for bridge and trestle timbers for solid members. Committee report. A. R. E. & M. W. Ass'n, 1908-9-317.

Standard specifications for southern yellow pine bridge and trestle timbers. (Final form recommended by committee of A. R. E. & M. W. Ass'n, for approval, 1910.) Now adopted. Reference: Proc. of Ass'n, Vol. 11, Part 1, pp. 180, 181; 1911 Year Book, pp. 141-143.

Standard Specifications for Structural Timber, by Ostrup, McGraw-Hill Book Company, pp. 58-64.

Standard classification of structural timber. (Adopted in Chicago on Sept. 1, 1907.) Reference: Handbook for Architects and Builders, Vol. 16, 1913, p. 237.

Grading Rules for Yellow Pine Lumber (copyrighted 1911 by Yellow Pine Manufacturers' Ass'n.). Reference: A Manual of Standard Wood Construction, No. 8861, pub. by above association, Geo. K. Smith, Secy., Wright Building, St. Louis, Mo.

Timber, Structural—Continued.

Definitions relating to structural timber. (Recommended for adoption by committee of A. R. E. & M. W. Ass'n, 1913.) Reference: Proc. of Ass'n, Vol. 11, part 1, p. 184. Corresponds to specifications of Am. Soc. for Test. Mat.

Standard specifications adopted by the American Society for Testing Materials, two specifications. 1913 Year Book, pp. 300-306. Note: Above Year Book contains all standard specifications of the society, about sixty-three or sixty-four in number.

Classifying Lumber, Southern Lumber Manufacturers' Association. Johnson, p. 204.

Grading Finishing Lumber, Southern Lumber Manufacturer's Association. Johnson, p. 207.

Standard Dimensions, Southern Lumber Manufacturers' Association. Johnson, p. 211.

Grading Common Boards and Rough Lumber, Southern Lumber Manufacturers' Association. Johnson, p. 209.

Rules governing the inspection and measurement of lumber in the St. Louis market. - Johnson, p. 212.

Thoroughly seasoned lumber. Johnson, p. 218.

File and trestle bridging, Union Pacific Ry. Co. Johnson, p. 238.

Criticism of some specifications. Editorial Comment. Lack of definiteness. Too little regard for commercial classifications. Eng. News, Vol. 53, Feb. 23 1905, pp. 203-205.

Specifications for lumber. (Adopted in 1910 as recommended practice by Amer. Ry. Master Mechanics' Ass'n, Master Car Builders' Ass'n, Railway Storekeepers' Ass'n, and various lumber manufacturers' associations.) Proc. M. C. B. Ass'n, Vol. 45, pp. 740-788.

Timber, Ties—

Report Am. Ry. Eng. & M. W. Ass'n specifications for ties. Eng. News, 1904-I-285.

Standard ties in United States, Canada and Mexico. Eng. News, 1900-II-142, 149, 215, 430.

Oak ties, specifications for. Eng. News, 1907-I-463.

Specifications for ties. Committee report. A. R. E. & M. W. Ass'n, 1905, Vol. 6, p. 764.

Specifications for ties, tie treatment, etc. Committee report. A. R. E. & M. W. Ass'n, 1906, Vol. 7, p. 34.

Timber Tie Markers—

Specifications for dating nail for marking ties. Report of committee.

A. R. E. & M. W. Ass'n, 1905, Vol. 6, p. 767; 1910, Vol. 11, p. 863.

See also "Timber, Treatment of."

Timber, Treatment of—

Treating Ties with Zinc Chloride and Tar Oil, by O. Chanute. Eng. News, 1900-II-80.

Atchison, Topeka & Santa Fe Ry. Specifications for treating Pacific coast piling and timber. Eng. News, 1908-I-366.

Timber, Treatment of—Continued.

Wood—Preservative Treatment, by Samuel Whinery. Eng. News, 1911-I-501.

Specifications for tie treatment. Committee report. Zinc chloride, zinc tannin, creosoting, zinc creosote. A. R. E. & M. W. Ass'n, 1906, Vol. 7, p. 34; 1907, Vol. 8, p. 476; revised 1910, Vol. 11, p. 737.

Preservation of Railroad Cross-Ties, by O. Chanute, Pres. Amer. Soc. of Civil Engineers. Johnson, p. 485.

Testing chloride of zinc and tar oil. Used for preserving timber. Johnson, p. 491.

Impregnating pine railroad cross-ties with a chloride of zinc solution with an addition of coal tar containing carbolic acid. Imperial railways at Strassburg. Johnson, p. 487.

Impregnating beech and oak railroad cross-ties, with hot coal tar oil containing carbolic acid. Johnson, p. 487.

See also "Oil, Bituminous."

Tires—

Standard specifications for steel tires for locomotives, etc. Proc. Am. Test. Mat., Vol. 9, 1909, p. 58.

See "Iron and Steel;" "Railway Rolling Stock."

Transmission Lines—

A Specification for Line Construction on Poles Jointly Used by Electric Light and Telephone Companies, by Paul Spencer. N. E. L. A., 31st Conv., Vol. I, 1908, p. 537.

Requirements and Specifications for Extra High Potential Transmission Lines, by A. S. Ives. Covers poles and appurtenances, insulation, wire, copper and aluminum and construction features. N. E. L. A., 32nd Conv., Vol. II, 1909, p. 389.

General Specifications for Underground Electric Conduit, by R. E. Froisetti. Eng. Cont., Jan. 10, 1912, p. 46.

Specifications for wire cables for electric power transmission. Proc. Am. Soc. Test. Mat., Year Book 1910.

Overhead wire crossings in Illinois. New laws governed by the Illinois railroad commission. Elec. World, Vol. 62, p. 39.

Telephone aerial lines. Electric World, April 25, 1903.

Specifications for furnishing and erecting telephone poles and appurtenances at various localities along line of Catskill aqueduct. "Contract No. 83" of the Board of W. W. of the city of New York, (Pamphlet.)

Specifications for steel cross-arm pins. (Brought before the Railway Signal Ass'n State Meeting March, 1912. These are practically the specifications of the Western Union Co.) Proc. of Ry. Sig. Ass'n, Vol. 9, p. A7-A13.

Specifications for Overhead Wires, adopted by the City of Seattle, Wash., by H. L. Estep. Eng. News, Vol. 67, p. 523.

Wiring. Of an office building, specifications for. Building of modern type, say twenty stories high. Wired for lights, telephone, electric

Transmission Lines—Continued.

clock connection, messenger calls and other service. Eng. Rec., Vol. 32, Sept. 7, 1895, pp. 261, 262.

Electrical distribution circuits for light and power, Austin, Texas. Johnson, p. 259.

Specifications for overhead crossings of electric light and power lines. (Recommended by committee of Nat. Elec. Light Ass'n in 1913.)

Reference: Papers, reports and discussions of the 36th annual convention of the Nat. Elec. Light Ass'n Technical Sessions, pp. 560-580. Note: Creation of national joint committee on overhead line construction recommended.

Specifications for High Tension Line Construction for the Oneida Railway Co., New York State, "Hydro Electric Developments and Engineering," by Koester, pp. 243-245.

Also see "Wire."

Tunnels—

Tunnels. Henry S. Drinker. Haupt, p. 161.

See also "Railways; and "Excavation."

Turbine Water Wheels—

Turbine water wheels. Water power system of Austin, Texas. Johnson, p. 252.

Turpentine—

Tentative specifications for turpentine. Proc. Am. Soc. Test. Mat., Vol. 13, 1913, p. 365.

Proposed specification for turpentine. Proc. Am. Soc. Test. Mat., Vol. 14, 1914, p. 342.

Valves—

Standard specifications for water works hydrants and valves (Am. W. Wks. Ass'n). Eng. News 1913-II-265.

Stop valves. St. Louis water department. Johnson, p. 200.

See also "Hydrants."

Viaduct—

Kingshighway—Reinforced Concrete, St. Louis, Mo., by Mont. Schuyler. Eng. News, 1912-I-1228.

See also "Bridge."

Water Meters—

Specifications of Baltimore, Md. Eng. News, 1902-II-356.

Specifications governing purchase of water meters of the disc type. San Diego, Cal. (materials and details). Eng. Cont., Sept. 23 1914, p. 291.

General specifications under which 3," 4" and 6" meters of velocity and disc types are purchased by St. Louis Water Dept. Eng. Cont., Feb. 25, 1914, p. 243.

Water Proofing—

Specifications for water proofing engineering structures with bituminous membranes. Paper before W. S. E., by W. H. Finley. Eng. Cont., July 10, 1912, p. 39.

Water Proofing—Continued.

Specifications for water proofing, Penn. R. R. Terminal, New York. Trans. A. S. C. E., Vol. 69, p. 211 (1910).

Water proofing of masonry and bridge floors. Condensed report of committee to Am. Ry. Eng. Ass'n. Eng. Cont., Mar. 25, 1914, p. 350.

Water Purification Plant—

Specifications for plant and material to sterilize Buffalo water supply by hypochlorite of lime or liquid chlorine (reprint of city specifications). Eng. Cont., Mar. 11, 1914, p. 297.

Water Works—see "Pumping Machinery;" "Steam Plant;" "Cast Iron Pipe;" "Hydrants;" "Valves."**Wells—**

Specifications for driving 12" wells in water bearing sands at San Diego, Cal. Abstracted from specifications by Maj. Herding. Eng. Cont., June 3, 1914, p. 639.

Pump well. Method of sinking well. Johnson, p. 249.

Wire—

Wire for Electric Transmission Lines, by F. A. C. Perrine and F. G. Baum. Eng. News, 1900-II-215.

Specifications for Telephone and Other Low Tension Wires Crossing Railway Tracks in Use by Bell Telephone Co. of Canada, by E. E. Parsons. Eng. News, 1906-II-496.

Specification for hard drawn copper, desirability of standard. Eng. News, 1908-II-32; 1909-II-56.

Hard drawn copper, notes on, annual meeting Am. Soc. Test. Mat. Eng. News, 1911-II-34.

Specification for overhead wires, Seattle (pole lines). Eng. News, 1912-I-523.

Standard specifications for hard drawn copper wire. Proc. Am. Soc. Test. Mat., Vol. 9, 1909, p. 311.

Specifications for aluminum wire. Am. Soc. Test. Mat., Year Book 1910.

Line wire. Recommended specifications for thirty per cent conductivity hard-drawn copper-clad steel line wire. (Discussed at 1912 meeting of Ry. S. Ass'n and committee asked to revise somewhat.) Proc. of Ry. Signal Ass'n. Vol. 9, pp. 79, 80.

Signal wire. Specifications for rubber insulated signal wire for current of 660 volts or less. (Adopted by Railway Signal Ass'n in 1911.) Proc. Am. I. E. E., Sept., 1911, Vol. 30, No. 9, pp. 2039-2042. Proc. of Ry. Signal Ass'n, Vol. 8.

Bonding wires. Recommended specification for copper-clad steel bonding wires. (Report of committee discussed; specifications not adopted at the 1912 meeting of the Ry. Signal Ass'n,) Proc. of the Ry. Signal Ass'n, Vol. 9, pp. 81, 82.

See also "Transmission Line."

Wiring—see “Transmission Line.”

Wood Preservatives—see “Oil;” “Timber Treatment.”

Zinc—

Zinc. Abstract of Pennsylvania R. R. specifications for materials. In practical use for several years. Reprint recommended by Soc. of Automobile Engineers standard committee, 1911.) Reference: Trans. of the Soc. of Automobile Engineers, Vol. 6, pp. 400-445. Standard specifications for spelter. Adopted 1911. Proc. Am. Soc. Test. Mat., Vol. 11, 1911, p. 146.
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